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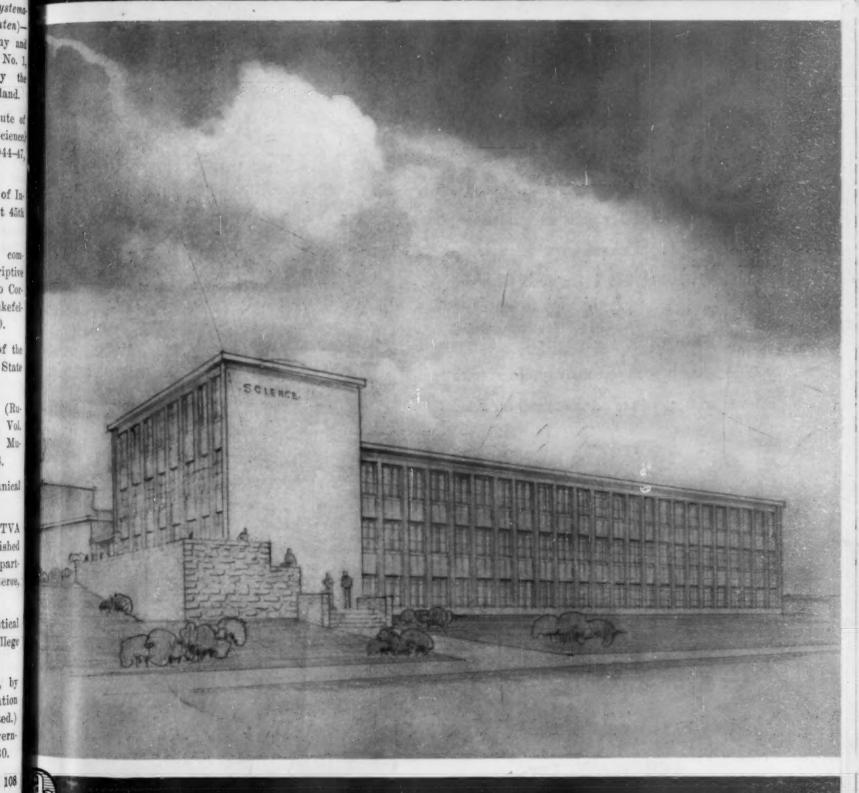
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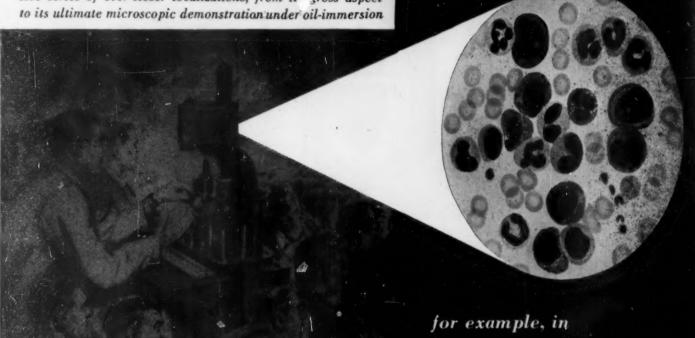
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## The Circulation of the Upper Troposphere and Lower Stratosphere

C. G. Rossby and H. C. Willett<sup>1</sup>
Massachusetts Institute of Technology

THE PRESENT DISCUSSION IS CON-CERNED primarily with the circulation of L the upper troposphere and lower stratosphere as it is observed to exist on the Northern Hemisphere of the earth. A number of idealized schemes for the general circulation of the earth's atmosphere have been proposed, starting with Hadley's thermal explanation of the trade winds as far back as 1735. None of the models or schemes of the general circulation as proposed up to the present has, however, been adequate to explain the observational facts which are being established by radiometeorograph and radar wind observations from the higher atmosphere. It is beyond the scope of the present paper to discuss at length the inadequacies and difficulties in the circulation models which have been proposed. It is intended, rather, merely to present certain facts of observation concerning the winds aloft which seem to conflict with the classical circulation scheme and to offer some tentative remarks as to the probable operation of the general circulation system.

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Unfortunately, it remains true today that observational data from the level of the tropopause in the atmosphere are quite restricted in length of record and in geographical distribution. Even at the 700 mb (3 km) level, Northern Hemisphere weather maps are seriously lacking in completeness. At the higher levels daily charts can be prepared with some degree of dependability, principally over North America and western Europe, whereas only along the 80th meridian west has it been possible to prepare cross sections through the troposphere, extending from above the Arctic Circle to the equator, based on an adequate number of radiometeorograph observations. Consequently, the present discussion is based principally upon observational data from these regions.

It is proposed (1) to note briefly, as the data per-

It is proposed (1) to note briefly, as the data permit, some features of the seasonal mean or normal state of the general circulation of the Northern Hemisphere, particularly in the vicinity of the tropopause; (2) to observe the character of the principal irregular (nonseasonal) variations of the circulation; and (3) to suggest tentatively some interpretation or explanation of the normal pattern of the general circulation and its large-scale irregular variations.

THE NORMAL STATE OF THE GENERAL CIRCULATION OF THE UPPER TROPOSPHERE AND LOWER STRATOSPHERE

The outstanding feature of the state of motion of the bulk (lower 9/10 of the total mass) of the atmosphere of the Northern Hemisphere, and undoubtedly also of the Southern Hemisphere, is the existence of an extensive circumpolar cyclonic (west-wind) vortex. This circumpolar vortex has its maximum intensity just beneath the tropopause, near the 12-km level, in middle latitudes, where the relatively narrow band of extreme west-wind velocity, which is bounded especially on the equatorward side by a zone of very sharp decrease of west wind, has been characterized by Rossby as a jet stream. This jet stream varies in intensity and latitude in a normal manner from season to season, irregularly from day to day, and also at the same synoptic time from meridian to meridian, in such a manner as to parallel the major wave pattern of the westerlies at the lower 500- or 700-mb levels.

The mean seasonal characteristics of the jet stream probably are most reliably represented by two vertical cross sections prepared by Seymor L. Hess, of the University of Chicago. Figs. 1 and 3, respectively, represent the mean east-west geostrophic wind velocity, in m/sec, for the winter months January-February and for the summer months July-August, at approximately the 80th meridian west, as given by the radiometeorograph observations from a line of sta-

This paper, which was presented in the Symposium on the Upper Atmosphere, held September 15, during the Centennial Celebration of the AAAS, is based primarily upon the work of Dr. Rossby and material prepared by his colleagues at the University of Chicago and in Stockholm. The general scope of the paper was planned jointly by the authors, but the final preparation of the article was made by Dr. Willett without benefit of discussion with Dr. Rossby, who was in Sweden at that time. Consequently all reference to, and interpretation or critical discussion of, the latter's work is expressed in the third person by Dr. Willett.

tions extending from Arctic Bay at 73° N to Salinas, Ecuador, at 2° S, for the years 1941–45. The winter section is of primary interest, for that is the season of the maximum intensity of the entire circulation, including the jet stream. It must be remembered that the sections in Figs. 1 and 3 represent conditions along one meridian only, and not an average of the

ness of the jet stream in winter. This fact is observed most clearly in Fig. 2, which represents the meridional velocity profile at the 12-km level of the mean geostrophic zonal wind from Fig. 1. The zonal wind speed in Fig. 2 is plotted in the form of the ratio to the rotational speed of the earth's surface at the equator,  $U/C_E$ . The sharpness of the jet stream in

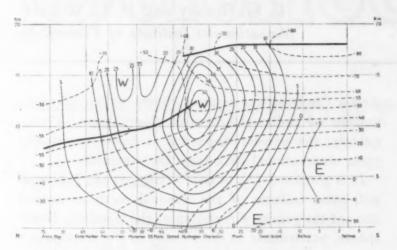


Fig. 1. Mean zonal geostrophic wind velocity and temperature, Arctic Bay to Salinas, for January-February.

hemisphere. It is probable that, owing to the normal presence of a trough of low pressure aloft over eastern North America, the jet stream in this section is moderately stronger and farther south, particularly in

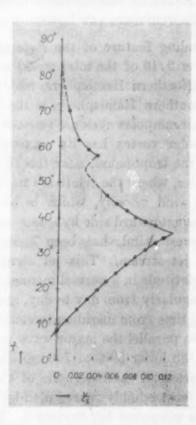


Fig. 2. Profile of the ratio of the mean zonal geostrophic wind at the 12-km level, from Fig. 1, to the rotational speed of the earth's surface at the equator.

winter, than the average of the hemisphere, but the difference is doubtless only one of minor degree.

Particularly striking in Fig. 1 is the extreme sharp-

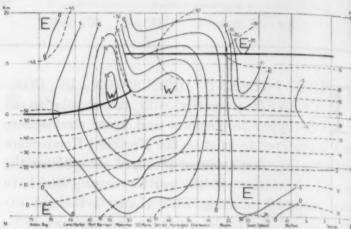


Fig. 3. Mean zonal geostrophic wind velocity and temperature, Arctic Bay to Salinas, for July-August.

the mean seasonal cross sections is particularly striking in view of the fact that considerable irregular fluctuation of both the latitude and the intensity of the jet stream is observed from day to day. In its daily synoptic occurrence the jet character of this current is much more pronounced, particularly along its lower latitude boundary, where the latitudinal wind shear becomes very great. An illustration of a typical zonal wind profile at time of strong development of the jet is illustrated by Fig. 11, prepared by E. Palmén (1).

A comparison of Fig. 1 with Fig. 3 indicates that in the seasonal mean the jet stream, which is less clearly defined in summer than in winter, shifts its position poleward from 35° to 55° and decreases its speed by half from winter to summer. This change is doubtless fairly typical of the entire Northern Hemisphere conditions. It might be noted that this seasonal shift of the jet stream may also be characterized as the deterioration of the principal low-latitude winter season jet and the emergence to relatively primary importance of a weak secondary jet which is present in the mean in winter also at 55° N. Another well-known feature of the seasonal variation of the zonal wind circulation, which is evident in these two sections, is the appearance of the deep subtropical easterlies in summer with a vertical boundary between them and the westerlies at about 28° N, while in winter the easterlies are greatly weakened and are displaced by westerlies in the upper troposphere to quite low latitudes.

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Figs. 4 and 5. (4, top) Northern Hemisphere flow pattern of relatively zonal character at the 700-mb level, January 19, 1939. (5, bottom) Northern Hemisphere flow pattern of relatively cellular character at the 700-mb level, January 29, 1937.

A very significant feature of the cross sections in Figs. 1 and 3, a feature which is most striking in the stronger winter circulation pattern, is the concentration of the principal latitudinal temperature contrast, or poleward temperature gradient in the troposphere, directly beneath the principal jet stream of the circumpolar vortex. The concentration of solenoids beneath the jet stream is indicated by the maximum poleward slope of the isotherms between latitudes 25° and 45° in Fig. 1. It is obvious, since the jet stream determines the latitudinal zone in which the west wind increases most rapidly with height in the troposphere, that the thermal wind relationship requires that this also be the zone of maximum poleward temperature gradient in the troposphere. However, it will be seen later that the maintenance of the jet stream, i.e. the question of the extent to which the corresponding solenoid field is to be considered a thermodynamic cause or a dynamic consequence of the jet, constitutes a primary problem in the interpretation of the mechanics of the general circulation.

Another obvious fact which is evident in Figs. 1 and 3 is that above the maximum jet level, at about 12 km, the poleward temperature gradient is reversed. The mean tropopause level, which is marked in Figs. 1 and 3 by a heavy black line, is quite clearly defined by the temperature field in the higher latitudes and in the lower latitudes, but there is a narrow zone in middle latitudes above the jet stream where it is rather indeterminate. This is the zone in which the tropopause level fluctuates greatly from day to day between the low polar tropopause and the high subtropical tropopause. It seldom extends in one continuous inversion layer through this latitude zone.

THE IRREGULAR VARIATIONS OF THE GENERAL CIRCU-LATION OF THE UPPER TROPOSPHERE AND

LOWER STRATOSPHERE

The circumpolar vortex with its jet-stream characteristics in the upper troposphere undergoes rather extensive irregular fluctuations from day to day and from week to week. These fluctuations are essentially threefold in character, namely:

- (1) There is a simple expansion or contraction of the circumpolar vortex, so that the jet stream is alternately closer to and farther removed from the pole.
- (2) A variation occurs in the speed of the jetstream maximum of the circumpolar vortex between values of approximately one-half to nearly double the seasonal normal values indicated in Figs. 1 and 3. There is a tendency for the maximum speed of the jet stream to be reached near or equatorward from its normal seasonal latitude, but not in the very lowest latitudes at which it is observed. The profile in Fig. 11 is typical of a strongly developed jet stream.
- (3) The circumpolar vortex, from the 700-mb level upward through the tropopause, normally possesses an undulatory wave character, which is more or less symmetrical about the pole, so that the pressure and wind patern at any level is marked by a succession of cyclonic troughs and anticyclonic ridges. The circumpolar vortex usually contains from 4 to 8 such waves. This wave pattern in the circumpolar vortex varies in wave length, which tends to increase with the speed of the westerlies, in the orientation of the pattern with respect to the meridians, and in the amplitude of the individual waves. This amplitude tends to increase as the vortex expands to lower latitudes. There is a tendency at times for this increase to continue until the wave character of the pattern breaks down in such a manner that the troughs are cut off as stationary closed cyclonic cells in middle latitudes and the ridges as closed anticyclonic cells in the higher latitudes. This variability of the wave pattern of the circumpolar vortex imposes much uncertainty on the interpretation of observed irregular variations of the jet stream in a restricted meridional zone or cross section, because the irregular variations caused by the changing wave pattern cannot be separated from those caused by expansion or contraction and changing speed of the circumpolar vortex as a whole.

Since this open wave vs. closed cell character of the circumpolar vortex is probably of as much mechanical or dynamic significance to the general circulation as it is of synoptic or prognostic significance, it is worth noting some details of the pattern change. Figs. 4 and 5 represent the Northern Hemisphere flow pattern at the 700-mb level at times, respectively, when the circumpolar vortex is relatively zonal in character

and when it is relatively cellular. Note in Fig. 5 th closed anticyclonic cells over the Aleutians and north of Scandinavia, and the strong closed lows over een tral Europe, the central Atlantic, the coast of Oregon

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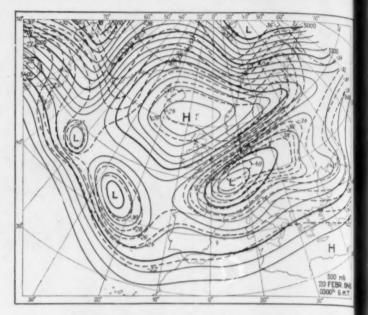
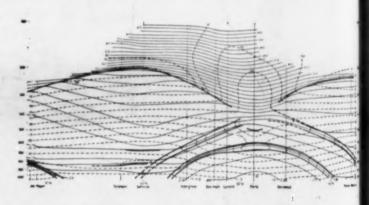


Fig. 6. Height contours and isotherms at the 500-mb le over the northeastern Atlantic and Europe, February 20, 1948

and the western Pacific. In Fig. 4 the strong zonal westerlies are centered just south of 45° N, which is the normal seasonal position, while in Fig. 5 the weak zonal westerlies are centered at about 35° N.

Fig. 6 represents at the 500-mb level, in more detail the cutting off of a strong anticyclonic vortex between Scandinavia and Iceland, with a series of cyclonic vortices moving in the westerlies to the south. The



Vertical cross section through the atmospher FIG. 7. Jan Mayen to Maison Blanche (Alglers), February 20, 1948

westerly jet in this case is split into two branches one in the far north from Greenland to northern Scandinavia, and the other dipping southward to the Mediterranean. A characteristic and noteworthy feature of these isolated vortical cells, as shown by the isotherms which are sketched in broken lines, is the marked warmth of the anticyclonic cells, which are en off from lower latitudes, and the marked coldness of the cyclonic cells, which are cut off from the higher latitudes. This temperature distribution is indicated even more clearly in Fig. 7, which represents the corresponding vertical cross section from Jan Mayen in the far north to Algiers in the south. The cold troposphere and the low warm tropopause and stratosphere

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Fig. 8. Height contours and isotherms at the 500-mb evel over the northeastern Atlantic and Europe, September 23, 1947.

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in the cyclonic cell and the warm troposphere and the high cold tropopause and stratosphere in the anticyclonic cell are unfailing characteristics of these deep vortical circulations. The question of the extent to which these thermal characteristics of the vortices are advected with the circulating air mass or are created dynamically on the spot is a moot one.

Figs. 8, 9, and 10 represent on three successive days, at the 500-mb level over western Europe and the north Atlantic, the successive steps in the cutting off of an isolated cyclonic vortex from a deep trough in a large-implitude wave in the westerlies. Once again it will be noted how the isobaric contours and the isotherms tend to parallel each other so that low temperature coincides with low pressure, and vice versa.

The synoptic and statistical analysis of Northern Hemisphere weather data from different levels in the atmosphere has led to the concept of an over-all basic but rather irregular cycle of change of the general circulation pattern. This cycle, which is usually best defined in winter, varies in period from 3 to 8 weeks and also in amplitude and regularity. Fundamentally, it consists of a fluctuation of the circulation pattern from a state which is essentially zonal in character, with a minimum of storminess and meridional, r air mass, exchange in middle latitudes—a pattern referred to as high index in character—to a state which is much less zonal and more cellular in character, with a maximum of storminess and meridional, or air mass, exchange in middle and lower latitudespattern referred to as low index in character. The high and low index designation refers essentially to the strength of the zonal westerlies.

Since this fluctuation of the general circulation between high and low index patterns seems to be in-

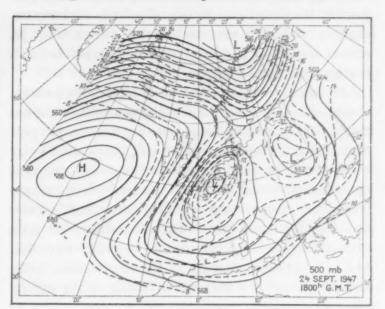


Fig. 9. Height contours and isotherms at the 500-mb level over the northeastern Atlantic and Europe, September 24, 1947.

herent in the mechanics of the operation of the general circulation, it is of interest to note briefly, as definitely as the observational data permit, how the zonal index cycle is related to the fluctuations of the

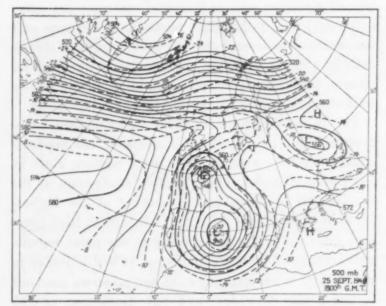


Fig. 10. Height contours and isotherms at the 500-mb level over the northeastern Atlantic and Europe, September 25, 1947.

circumpolar vortex and jet stream at the top of the troposphere.

For the correlation of the jet-stream cycle with the zonal index cycle, four principal stages of the index cycle are recognized, each of which can be briefly characterized essentially as follows:

(1) Initial high index (strong sea-level zonal westerlies), characterized by (a) sea-level westerlies

strong and north of their normal position, long wavelength pattern aloft; (b) pressure systems oriented east-west, with strong cyclonic activity only in higher latitudes; (c) maximum latitudinal temperature gradient in the higher middle latitudes, little air mass exchange; and (d) the circumpolar vortex and jet stream expanding and increasing in strength, but still north of the normal seasonal latitude.

(2) Initial lowering of sea-level high-index pattern, characterized by (a) diminishing sea-level westerlies moving to lower latitudes, shortening wave-length pattern aloft; (b) appearance of cold continental polar anticyclones in high latitudes, strong and frequent cyclonic activity in middle latitudes; (c) maximum latitudinal temperature gradient becoming concentrated in the lower middle latitudes, strong air mass exchange in the lower troposphere in middle latitudes; and (d) maximum strength of the circumpolar vortex and jet stream reached near or south of the normal seasonal latitude.

(3) Lowest sea-level index pattern, characterized by (a) complete breakup of the sea-level zonal westerlies in the low latitudes into closed cellular centers, with corresponding breakdown of the wave pattern aloft; (b) maximum dynamic anticyclogenesis of polar anticyclones and deep occlusion of stationary cyclones in middle latitudes, and north-south orientation of pressure cells and frontal systems; (c) maximum east-west rather than north-south air mass and temperature contrasts; and (d) development of strong troughs and ridges in the circumpolar vortex and jet stream, with cutting off of warm highs in the higher latitudes and cold cyclones in the lower latitudes.

(4) Initial increase of sea-level index pattern, characterized by (a) a gradual increase of the sea-level zonal westerlies with an open wave pattern aloft in the higher latitudes; (b) a gradual dissipation of the low-latitude cyclones, and a merging of the higher-latitude anticyclones into the subtropical high-pressure belt; (c) a gradual cooling in the polar regions and heating of the cold air masses at low latitudes to re-establish a normal poleward temperature gradient in the higher latitudes; and (d) dissipation of the high-level cyclonic and anticyclonic cells, with a gradual re-establishment of the circumpolar vortex jet stream in the higher latitudes.

### A Possible Mechanism of the Circulation of the Upper Troposphere

It is evident that the large-scale fluctuations of the general circulation of the Northern Hemisphere throughout the troposphere and probably well into the stratosphere must be closely tied together in some coordinated dynamic or thermodynamic system. It is necessary in the light of the recently acquired observational information on the circulation of the upper troposphere to look critically at the classically accepted notion as to how this circulation works.

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In their essential features, the classical explanations of the general circulation depend on two principles (1) the circulation principle, which expresses the tendency of the atmosphere in the presence of a horizontal temperature gradient to develop a thermally direct circulation from the warm to the cold region aloft and from the cold to the warm region at the ground; and (2) the principle of the conservation of angular momentum, which requires poleward-moving air masses on the rotating earth to acquire relative eastward velocity and equatorward-moving air masses to acquire relative westward motion.

According to these principles, thermally direct cells with northerly to easterly winds at the surface and southerly to westerly winds aloft are maintained between the pole and approximately 60° N latitude, and between the thermal equator and approximately 30° latitude, at which the equatorial outflow aloft has become deflected to a westerly current. In each of these thermally direct cells, rising motion must occur on the equatorward side and sinking motion on the poleward side, while the easterly wind component at the surface must decrease and become a westerly component aloft. These circulations require, at sea level, belts of minimum pressure at the equator and at 60° and subtropical high pressure belts at 30°. This pressure distribution must be reversed in the upper troposphere.

Between these two thermally direct cells there must exist in middle latitudes a third cell with west winds at sea level. Since surface friction insures some pole ward movement of air in this cell at lower levels, it must be a thermally indirect circulation which is forced by the two direct cells flanking it. This circulation requires that the equatorward return of air must take place in this cell in the upper troposphere, either as an easterly current (by conservation of angular momentum) or as a forced (supergradient) westerly current.

It follows from this concept of the general circulation that there is a tendency to produce west winds in the higher latitudes wherever air motion is poleward as a result of the transport of angular momentum from the lower latitudes, and, conversely, to produce east winds at lower latitudes wherever the air motion is equatorward. In general, in so far as the angular momentum principle holds in meridional air mass exchange by means of large quasi-horizontal cells, it matters little whether the meridional circulation within a zonal cell is uniformly zonal in character or whether, corresponding to the observed facts,

it tends to be more cellular in character. In either case the net effect of the exchange must be to produce a relatively westerly flow in the northern portion of the zone and an easterly flow in the southern portion.

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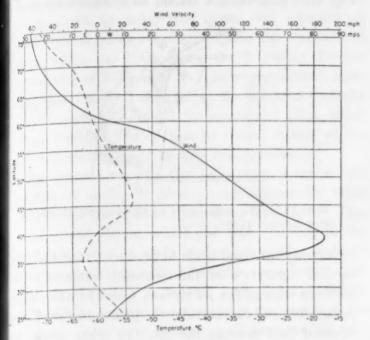


FIG. 11. Distribution of temperature (dashed curve) and geostrophic zonal wind (solid curve) at the 200-mb level along the meridian 80° W for January 17, 1947.

It has long been realized with the increasing amount of observational data on the general circulation that in many ways this circulation fails to meet the requirements of the classical theory as indicated above. Rossby (4) has recently discussed a number of points at which the disagreement is notably evident, particularly the following:

- (1) In the tropics there exists no horizontal latitudinal temperatures gradient such as is required by a thermally direct cell of the Hadley type. Consequently, the east winds do not decrease with height, but extend to the top of the troposphere, even with some increase near the tropopause.
- (2) Furthermore, the wind structure in the tropics is much too complex, indicating, instead of a single thermally direct cell, probably two or more cells which are partly forced in character.
- (3) In middle latitudes, far from decreasing with height, the west winds increase to the jet characteristics of the circumpolar vortex at the top of the troposphere.

It is this increase of west wind with height in middle latitudes which has been the greatest obstacle to the concept of a middle indirect cell in the zonal wind system. Rossby (2) made the first real attempt to obviate this difficulty by assuming that the upper westerlies in middle latitudes are frictionally driven at supergradient velocity so that air is thrown southward against the pressure gradient and piled up in

the subtropical high-pressure belt, whence it sinks and is removed to lower latitudes in the surface trade winds and to higher latitudes in the surface westerlies. This frictional drive is effected supposedly by the upper-level westerlies in the two flanking thermally direct cells by means of large-scale horizontal (cellular) turbulent exchange.

This explanation has been rendered untenable by more recent aerological observations. If the momentum principle is retained, it is apparently impossible to account for any such phenomenon as the circumpolar jet stream by lateral frictional drive from the adjacent cells. Furthermore, it is not reasonable to expect to find in the mean a forced circulation cell filling the entire middle-latitude zone, where the principal concentration of circumpolar solenoids (poleward temperature gradient) occurs throughout the troposphere.

Recognizing these difficulties, Rossby (3) initiated a new attack on the problem. He points out that

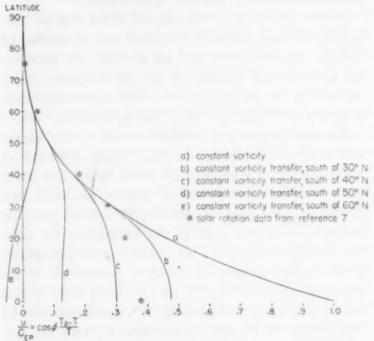


Fig. 12. Distribution of zonal motion in a thin atmospheric shell, measured relative to the underlying planetary surface, and expressed in fractions of the equatorial linear velocity of the planet. All profiles computed on the assumption that the polar angular velocity of the shell is equal to the angular velocity of the planet itself.

there is good reason to expect that lateral mixing in a thin hemispherical shell on a rotating globe, corresponding to any planetary atmosphere, should effect an equalization of absolute vorticity rather than one of angular momentum. He computes the zonal velocity profile in such an envelope on the assumption that the vertical component of the vorticity of the absolute motion should be independent of latitude and equal to that of the planetary rotation at the pole (Fig. 12). He points out the similarity of this profile to that of the observed velocity of the solar atmos-

phere from the poles to about 30° heliographic latitude. Equatorward from this latitude the solar velocity profile approximates that required by constant latitudinal transport rather than by constancy of the absolute vorticity (Fig. 12). He refers further to the established existence in some of the major planets (Jupiter, Saturn) of equatorial "accelerations," which might best be explained as a consequence of vorticity transfer.

Rossby assumes that it is only in the upper troposphere, beyond the influence of surface friction, that the full effect of the vorticity transport should be reflected in the zonal wind distribution. He has observed in numerous cases of strong jet-stream development in the upper troposphere the essential similarity of the zonal velocity profile to that of constant vorticity (not necessarily the vorticity of the pole, but frequently that at some lower latitude, as in Fig. 11) southward to the jet-stream maximum, at which point the profile changes discontinuously to one suggesting constant vorticity transport equatorward.

Rossby conceives of the general circulation as fluctuating through cycles of activation and relaxation of the circumpolar vortex and jet stream. He indicates the zonal cellular pattern at time of maximum development of the jet in Fig. 13. This figure represents a period of strong lateral mixing by means of quasihorizontal eyclonic and anticyclonic cells in the higher and middle latitudes or, in other words, a period of breakdown of a sea-level high index into a low index pattern. The intense lateral mixing produces uniformity of the absolute vorticity, of a value probably somewhat less than that of the rotation at the pole, in a broad circumpolar zone of the upper troposphere, a zone which includes in its outer portion all of the principal areas of frontal and cyclonic activity and which is sharply bounded on the equatorial side by the strong jet stream. Equatorward from the jetstream maximum the zonal westerlies decrease very sharply in a narrow zone in which the vorticity decreases rapidly as the regime of constant vorticity transport takes over. This sharp shear zone constitutes a horizontal negative vorticity inversion in the same sense that a vertical positive potential temperature inversion marks the top of a layer of turbulent mixing and constant potential temperature. During the preceding period of intensification of the jet it is displaced southward by the strong lateral mixing in the same sense that the turbulence inversion level is raised by continued strong vertical mixing, i.e. a broader zone of atmosphere is incorporated into the constant vorticity regime.

It is probable that a limit is placed on the development of the jet by the inertial stability of the atmosphere. When the zonal wind shear at the outer edge of the jet stream exceeds that which corresponds to constancy of angular momentum, a narrow, indirect, forced meridional circulation develops, as indicated in Fig. 13. This feature should be normal with strong

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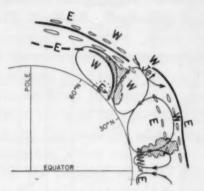


Fig. 13. The zonal cells of the general circulation (after Rossby, 1948).

jet development and tends to produce dynamically the vertical separation of the isentropic surfaces at the southern edge of the jet stream, which lifts the tropopause aloft and concentrates the principal circumpolar solenoid field beneath the jet. In other words, the strong concentration of solenoids which must account pany strong jet-stream development is essentially dynamically produced by the kinetic energy of the stream. The energy of the jet stream, then, is to b considered a cause rather than an effect of the local solenoid field. The energy of the forced jet stream has its origin in the widely distributed quasi-horizontal cellular circulations which force the lateral transport and equalization of vorticity. Both synoptic observa tion and theoretical reasoning (4) indicate that the kinetic energy which is released in any quasi-horizontal circulation is rapidly dispersed downstream in the westerlies around the globe and that kinetic energy obtained from many such sources would, by such dispersal, ultimately accumulate in one or more jet streams. Hence, according to Rossby, there is my longer any compelling reason to build the theory the maintenance of the general circulation exclusively on direct meridional-solenoidal circulations, i.e. it permissible to accept the dynamic maintenance forced circulation of a meridional solenoid field that is stronger than those which exist in the driving branches of the general circulation.

Equatorward from the indirect meridional circulation cell Rossby assumes a continuation of the same constant transport of vorticity. The inertial stability of the zonal wind profile in the large, thermally direct, zonal cell of the subtropics requires that the transport shall take place in the quasi-horizontal cellular circulations as in the higher latitudes. This transport is assumed to continue through the equatorial zone, where the relative constancy of angular momentum may per-

mit two or more direct meridional cells of the Hadley type, as Rossby has indicated in his sketch (Fig. 13). Two or more such cells combined with the effects of constant transport of positive vorticity from the Northern Hemisphere, or of negative vorticity from the Southern, probably lead to the very complicated wind systems which are observed near the equator and about which too little is known to justify further speculation at this point. It is to be emphasized, however, that Rossby assumes that the constant vorticity transfer extends through the equatorial zone, which effects a certain cancellation by lateral mixing of the opposite vorticity of the two hemispheres.

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The deterioration of the jet stream, when it has reached its strongest development, apparently takes place during the period of lowest sea-level index. This is the period during which the wave pattern in the circumpolar vortex aloft becomes unstable, with increasing amplitude and shortening wave length, terminating with the movement into higher latitudes and seclusion of warm anticyclonic vortices and the movement into lower latitudes and seclusion of cold evelonic vortices. In other words, the interaction of cold and warm air masses (occlusion process) reaches its ultimate development by extending to the top of the troposphere and diminishing latitudinal temperature contrasts at all levels. The deterioration of the jet stream in the lower latitudes follows rapidly and, with that, a period of relaxation of the circumpolar vortex. Apparently the westerlies aloft are gradually reactivated in the higher latitudes by the slow radiational cooling of the polar troposphere and consequent sharpening of the poleward temperature gradient, preparatory to another cycle of index change. Rossby visualizes this cycle of index change as having a natural period which depends upon the relative effectiveness of the radiational cooling processes in the higher latitudes. This period appears to be shorter at the beginning of the cold season than it is later, perhaps because the zone of effective polar coldness is more restricted to the immediate vicinity of the pole at the beginning of the winter and because the rate of cooling is most rapid at that time. Each index cycle tends somewhat to expand the effective polar cap and to diffuse thermal contrasts equatorward.

Rossby's application of the vorticity theorem to the atmosphere accounts very handily for the jet-stream characteristics of the circumpolar vortex and offers a very plausible explanation of the general sequence of events which typifies a major cycle of variation of the general circulation pattern. In contrast to the angular momentum theorem, the vorticity theorem requires that the strong zonal westerlies be driven from the higher latitudes rather than from the lower. In fact,

Rossby's insistence on the continuous equatorward transport of vorticity in the higher atmosphere as an essential feature of the basic mechanism of the general circulation requires that, likewise, a continuous net transport of angular momentum equatorward must characterize the normal state of the general circulation. If this condition is fulfilled, it necessitates that the troughs and ridges of the circumpolar vortex in the upper troposphere must, on the average, have a certain northwest-southeast orientation of their axes, so that in the mean the gradient wind crossing any latitude circle from north to south shall have more eastward motion than the gradient wind crossing from south to north. Furthermore, as Victor Starr (5) has pointed out, since angular momentum can be effectively supplied to, or removed from, the atmosphere only through surface friction at the ground, a net equatorward transport of angular momentum by the atmosphere requires either a relatively strong zone of polar easterlies compared to subtropical easterlies or a one-way transport of angular momentum from the subtropical easterlies of either hemisphere across the equator, i.e. a mutual cancellation of vorticity (and momentum) between the two subtropical easterly belts. There is no observational evidence that either of these conditions is fulfilled. In the mean the subtropical easterlies at the ground are much stronger and cover a much greater area than the polar easterlies. Hence, there must be more angular momentum supplied to the atmosphere in the lower latitudes. Starr (5) has made an effort to evaluate the latitudinal transport of angular momentum from the sea-level, 700-mb, and 500-mb Northern Hemisphere isobars. He finds almost without exception a substantial poleward transport of angular momentum at these levels in middle and lower latitudes on the Northern Hemisphere. Consequently, it remains to be proved just to what extent the westerlies of middle latitudes are driven from the polar or from the equatorial side and how much of a role the local solenoid field may play directly in their acceleration.

From a consideration of the long-period changes of the general circulation pattern, the changes that are reflected in the secular, climatic, and geological variations of world weather, one point should be noted. Willett (6) has suggested that there is a striking basic similarity between these long-period variations of the world weather patterns and the week-to-week cycle of high- and low-index patterns. Particularly in connection with the double sunspot cycle, there is considerable statistical and synoptic evidence of a definite influence of irregular solar variability on the index characteristics of the general circulation pattern. The inference is made that irregular solar activity may be

a controlling factor in all of the extensive long-period fluctuations of the general circulation.

No real attempt has been made as yet to explain how this solar variability directly affects the circulation patterns. However, if the effect is there in the long-period variations, and since the shorter-period variations are similar in character and the sun is known to undergo quite violent short-period variable activity, the possibility is by no means excluded that the irregular short-period variations of solar activity also affect the changing index patterns of the general circulation. If this is the case, it might help to explain the fact that the ordinary cycles of index change of the general circulation are so variable and erratic from cycle to cycle, and between different years, that

statistical analysis fails to yield significant indications either of regular periodicity or of regular lag effects in the change of the general circulation pattern.

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### TECHNICAL PAPERS

### Some Experiments in the Freezing of Water

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Although the supercooling of water is recognized as a very common occurrence, numerous reports have recently been published about it.

In our research we have found that the freezing of water without supercooling would be much more surprising, since we have so far been unable to find anything which will cause freezing at  $0^{\circ}$  C, except in contact with ice. Normally, water will not freeze until it is cooled to about  $-20^{\circ}$  C.

Lately, Rau (8) claimed to have cooled water to -72° C before it froze. He accomplished this by means of a "system of successive sterilization of the nuclei of solidification." After the publication of this work, Bangham (1), Frank (4), and Ubbelohde (10) attempted to explain this phenomenon and also to predict certain properties of water in the low-temperature range. Since then, Cwilong (2) has tried to repeat Rau's experiment and has proven Rau's measurements to be invalid.

Another reported case of the low-temperature freezing of water is stated by Oltramare (7). He reported that R. Pictet and L. Dufour had cooled water to  $-40^{\circ}$  C, but no paper by either Pictet or Dufour gives this value.

Martin (6) cooled water to -26° C by repeated distillation in vacuo without ebullition.

The above experiments were carried out on water in bulk. On the other hand, Vincent J. Schaefer (9) found that a supercooled water-droplet cloud dispersed in air, in the absence of sublimation nuclei, spontane-

ously changes to an ice-crystal cloud when any portion of the cloud is cooled to -38.9° C or lower. A few ice crystals can be observed at a slightly higher temperature, but the above temperature may be regarded as critical.

Bernard Vonnegut (11) found a number of foreign particles, most notably silver iodide, which cause the transformation from a water-droplet cloud to an ice-crystal cloud at considerably higher temperatures. He obtained varying results, depending not only on the material of which the particles were composed but on their crystalline structure, size, etc.

Cwilong (3) has also made measurements of the sublimation temperature in the atmosphere and claims a value of -41.2° C for spontaneous ice-crystal formation in pure air and about 9% warmer for impure air.

In Cwilong's experiment in a Wilson Cloud Chamber, the minimum temperatures reached were calculated and not measured. Furthermore, the presence of ice crystals was shown by their seeding action on a sample of supercooled water. In Schaefer's experiment, the temperature was measured directly and held constant, and the ice crystals observed visually and samples obtained. The validity of his results seems beyond criticism, and his temperature of  $-38.9^{\circ}$  C should, therefore, be accepted as more exact.

Cwilong's assumption that ions act as sublimation nuclei has not received support from our experiments. In a forthcoming paper, Schaefer will describe a number of foreign-particle sublimation nuclei and their relative effectiveness at various temperatures.

I. Langmuir, in a paper not yet published, reports that he has conceived of a mechanism for the spontaneous nucleation of a supercooled cloud. His explanation is based on the existence of an air-water interface. According to the Langmuir hypothesis, it should be possible,

herefore, to cool water out of contact with the air below he critical temperature found by Schaefer and in conact with air down to this temperature.

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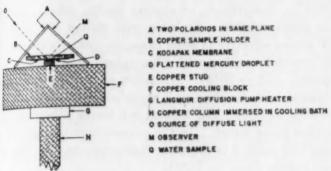
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In an effort to test this hypothesis, the following reezing experiments were carried out. These, although not yet complete, are significant. The apparatus used s shown in Fig. 1.



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The water sample to be frozen was supported on a Kodapak membrane (a certain type of cellulose acetate) tretched across a 4" hole in a 4" copper plate. Orignally it was planned to eliminate the air-water interface by laying another Kodapak film across the water surface, hereby completely enclosing it. The first experiments described below were done, however, without this cover, and the water sample was exposed to the air. The sample was then lowered onto a mercury-covered copper stud about 1" in diameter and in thermal contact with cooling system whose temperature could be accurately ontrolled. In this way no air-solid interface, below C, was in contact with the liquid. The presence of ice, clear or opaque, could be recognized by means of a polarized beam of light which passed through the sample, was reflected from the mercury surface, and reached the observer through another polarizer with its plane of polarization parallel to the first. The presence of ice caused birefringence which could be easily detected.

Considerable work was done in devising techniques for satisfactorily cleaning the surfaces and purifying the water. It was found that loosely adhering dust on the fresh Kodapak surface could best be removed by simply rolling drops of distilled water across it. Examination under a microscope was used to make sure no dust or dirt remained. Various methods of purifying water were tried, among them distillation, condensation, diffusion through a Formvar membrane, and pressure filtering.

Many freezing runs have shown the crystallization temperature to be independent of the rate of cooling, the previous history, such as previous freezing, and the temperature to which water has been raised to between freezing cycles.

Data from four sets of experiments give an average crystallization temperature of  $-19.2^{\circ}$  C, with a maximum of  $-18.0^{\circ}$  C and a minimum of  $-20^{\circ}$  C: (1) -19.0, -18.0; (2) -19.5, -20.5; (3) -20.0, -19.2; (4) -18.0, -20.0.

These results show that the supercooling of water is not at all an unusual phenomenon. The normal tempera-

ture at which water freezes is, therefore, in the absence of any known foreign nucleating materials, very close to -20° C and not, as is commonly believed, at 0° C. It might also be mentioned that considerable vibration was present during all of the above tests but had no observable nucleating effect. Various means were employed to make sure that the exact temperature in the sample was known, and they all showed that the readings were reliable. One way was to check on the melting point of the ice when the temperature was rising; another was to bombard the sample surface continuously with ice nuclei streaming from a tiny piece of dry ice held directly above it and observe when freezing took place.

A number of powdered materials were introduced to the sample in an attempt to make the water freeze at 0° C. So far, nothing has been found which can effect this. Some results follow:

Material		$^{\circ}C$		Average °C		
Aquadag	- 7.2,	- 6.8,	- 6.8		- 6.9	
Silver iodide	- 8.0,	- 9.5,	- 9.0,	- 9.0	- 8.8	
Graphite "280"	- 8.8,	- 9.8,	- 9.8,	- 9.8	- 9.5	
Zinc sulfide	-11.0,	- 11.6,	-12.2,	-12.3	-11.5	
Zinc oxide	-13.0,	-13.5			-13.3	
Iodoform	- 13.7,	-13.7,	-13.2		-13.5	
Lead sulfide	- 11.8,	-12.3,	-14.3			
	- 13.8,	-15.3,	-13.9		-13.9	
Sulfur	- 15.0,	-14.8,	-15.6		-15.1	
Zinc oxide (dri- filmed)	- 18.0,	- 17.0,	- 16.5		- 17.1	
Pepsin (surface)	-20.3,	-16.5,	-17.0		-17.9	
AgI ppt from acetone	-18.0				-18.0	

There is one interesting conclusion to be drawn from the above observations. Graphite has been tried in many ways as a sublimation nucleus for ice and is found to be practically without effect. However, as a freezing nucleus (in water), it seems to be even more efficient than silver iodide. This means that we must distinguish between "sublimation" nuclei and "freezing" nuclei and recognize that the mechanism of nucleation in each case is different.

The possibility immediately suggests itself that very often crystallization in bulk water may be started by a chance contact with a "sublimation" nucleus rather than by a "freezing" nucleus already contained in the liquid. It also suggests the possibility of cooling water considerably below 0° C and keeping it there indefinitely when care is taken to eliminate the introduction of sublimation nuclei as well as freezing nuclei. Having pure water is not enough.

Recently LaMer and Yates (5), at Columbia University, conducted experiments on the precipitation of sulfur from dilute solutions of sodium thiosulfate and HCl. They found that ultrasonic irradiation of the water of which the solutions were subsequently made caused a delay in detectable precipitation of approximately four times the normal. This technique was tried in our experiments, and we found that irradiating a sample in a methyl methacrylate container, at one megacycle for

<sup>&</sup>lt;sup>1</sup> This method of preventing supercooling was suggested by Vincent J. Schaefer.

30 sec, had a pronounced effect on the crystallization temperature of the water. This water retained this property even after standing two months in a bottle.

Five measurements of crystallization temperature were made on this water, each measurement being made on a new surface using a new sample of water:  $(1) - 38.5^{\circ}$  C,  $(2) - 28.7^{\circ}$  C,  $(3) - 28.5^{\circ}$  C,  $(4) - 30.0^{\circ}$  C,  $(5) - 29.0^{\circ}$  C.

All these measurements were made with the water sample in contact with air, and in each test the temperature was checked by noting the melting point with rising temperature.

It was found that freezing took place in two different ways at low temperature. Often the water seemed to freeze with great rapidity from many locations to form an opaque, milky ice easily recognized by the naked eye. The freezing sometimes took place in an altogether different manner, however, and could be observed only through polaroids. In these cases, single, beautifully colored crystals could be seen to grow slowly out from widely separated nuclei. Sometimes only one crystal developed in a whole water sample.

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### Internal Suberization of Plant Tissues

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Suberization of the internal surface, i.e. of the intercellular spaces, has been reported in the leaf of the Valencia orange, Citrus sinensis (4). Intercellular spaces in the mesophyll of the lamina and in the tissues of the petiole and of the basal and laminar abscission regions are lined with a thin film,  $\pm 1\,\mu$  in thickness, which resembles the cuticle in its refringence. A similar but more tenuous pellicle lines the inner surface of the cell wall and resembles a tertiary lamella. The films were first identified during the investigation of plasmodesms and cell walls while using a standard cellulose test, 1K1 followed by irrigation with H<sub>2</sub>SO<sub>4</sub> ( $\pm$ 80%). Both films, extracellular and intracellular, stain yellow with 1Kl and darken on irrigation with H<sub>2</sub>SO<sub>4</sub>. During and after the blue coloration, the swelling, and ultimate solution of the cellulose

of the cell wall, the films remain more or less intact. The degree of persistence depends on film thickness and there fore on the age and, to some extent, on the region of the leaf, since the swelling of the cellulose naturally disrupt all except the heavier coatings and impregnations.

The results obtained in citrus and other plants will 1Kl-H<sub>2</sub>SO<sub>4</sub> may be confirmed by the use of other reagent. When sections of fresh material are mounted directly in glycerin, lactophenol, or similar media, suberin pellicle are clearly visible. Staining with Sudan III or Suda IV proves effective in some cases, particularly if precede by treatment either with phloroglucin and HCl or with chromic acid (±50%). Irrigation of sections with strong chromic acid dissolves wall materials such as peetic substances, cellulose, and lignin, but leaves suberized membranes along intact. In the examination of lignified to sues this method is therefore indispensable, since ligning not broken down by H<sub>2</sub>SO<sub>4</sub>.

The leaves of sycamore, avocado, castor bean, and squash were examined at the same time and with the same techniques as used in citrus, and the results obtained were similar. It therefore appeared probable that suberization might occur generally in all tissues of vascular plants throughout the plant kingdom. The present survey of more than 50 species confirms this surmise. The plant selected differ in habit and habitat, and incidentally in phylum and family, and include annuals and perennials xerophytes, mesophytes and hydrophytes, pteridophyte and spermatophytes.

In this and in the previous paper the term subering used in preference to cutin, since by current microchemical methods these substances cannot be distinguished satisfactorily. Subering is more widely distributed than cuting and it is identifiable macrochemically in deep-seated the sues such as endodermis. It also occurs in the wound cork which may differentiate in parenchymatous tissues after deep or surface wounds, and it is in the principal component in the walls of normal cork cells (1, 2).

Suberin appears first in the intercellular spaces of differentiating tissues such as leaf mesophyll, and the parenchyma, cortex, and pith of stem and root. When first observed the films are at the limit of visibility and there after, during tissue growth, increase in thickness. Subtriction may extend sooner or later along the middlamellae but does not interrupt the plasmodesms between adjacent cells.

Suberin films are not confined to intercellular spaces but occur also within the cell. A tenuous film which resembles a tertiary layer of the cell wall may be identified soon after the first appearance of the intercellular suberin. It is similar in translucence and in chemical

¹ Some of the species examined were: Pteridium aquilinum. Selaginella Bigelovii, Araucaria imbricata, Pinus Coulter, Potamogeton sp., Clivia miniata, Iris Pseudacorus, Musinana, Eichhornia crassipes, Nymphaea alba, Macadamia terrifolia, Annona cherimola, Persea americana, Crassula arborescens, Bergenia cordifolia, Platanus racemosa, Vicia Fabl. Cercidium floridum, Dalea spinosa, Citrus sinensis, Ricinus communis, Mangifera indica, Acer macrophyllum, Aesculus californica, Jussiaea repens, Primula polyantha, Asclepius subulata, Acanthus mollis, Cucurbita Pepo, Echinocystis macrocarpa, Venegazia carpesiodes, Cynara scolymus.

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Suberin is observed in tissues of all types, parenchyma. nd sclerenchyma, and also in the phloem and xylem of nscular strands. The differentiation of a secondary, order-pitted vessel segment in Ricinus communis may be ken as typical. The differentiating element begins to apand as soon as it is cut off from the parent cambial At this stage the cell wall appears in surface view , a cellulose net, the roughly hexagonal meshes of which  $_{re}$  perforated by closely set plasmodesms less than 1  $\mu$  in iameter. In the profile of the cell wall, the plasmodesms re observed connecting the protoplasts of the differentiting adjacent cells, vessel segments, fibers, xylem paenchyma, or rays. Deposition of the secondary wall ecomes marked when the vessel segment reaches its maxiam diameter. About this time extracellular and intraellular suberin layers are now visible. The former is rident in the middle lamella between the differentiating viem element and the adjacent cells, whereas the latter orms a tertiary coating on the interpit reticulum of the condary thickening of the cell wall. Although interllular spaces are not obvious microscopically in differitiating vascular tissues, extracellular suberization apears to begin, as in the leaf mesophyll, at cell corners, resumably regions of growth strain, and extend thereom along the middle lamella.

As wall growth continues, the mouths of the pits are arrowed by the overhang of the cell wall, and sooner or ater lignification of the wall occurs. Meantime the intraellular suberin pellicle has increased considerably in hickness. As the end walls of the vessel segment disppear and the protoplast eventually dies, the plasmolesms withdraw from the pit areas, but leave behind a 
membrane which seals the base of the pit. Incidentally, 
his withdrawal presumably explains the absence of plasmodesms in the walls of lignified elements. The mature 
tylem vessel is thus completely lined throughout its length 
with a suberized membrane.

The differentiation and ultimate suberization of spiral ressels is essentially similar in pattern. Plasmodesms may be observed during early stages of growth (3), while the final suberization, extra- and intracellular, may be lemonstrated by careful treatment with 1Kl-H<sub>2</sub>SO<sub>4</sub> (weak) or occasionally merely by staining fresh sections

Sudan III or Sudan IV.

The fact that suberin occurs apparently around and within all living cells in the numerous tissues so far exmined appears to call for consideration in future discussions of such theories as transpiration, conduction, abecission, cellulose deposition, and permeability. A more letailed account of the work is in course of preparation.

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### Effect of Coconut Milk on the Growth of Explants From Carrot Root

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Explants derived aseptically from the cambium and near cambial region of dicotyledonous plants have furnished a major source of material for growth experiments by the accepted techniques of tissue culture. In the hands of Gautheret and Nobécourt particularly (7, 11), and with the use of indole-3-acetic acid, the indefinite culture of sterile explants from carrot roots became a demonstrable fact. These investigations following long-standing observations upon regeneration at cut surfaces exposed to air of many storage organs (13). This regeneration may take the form of periderm formation, as in the potato tuber, or a more diffuse proliferation stimulated in the region of the cambium (carrot, beet, etc.).

Our investigations stemmed from the desire to use sterile plant tissue cultures as experimental material with which to study the metabolism and behavior of growing cells. Several limitations of accepted plant tissue culture technique had to be overcome. As commonly grown, plant tissue cultures-even clones subcultured from the same source (4)—are very variable in growth rate. Secondly, though the growth is impressive, it is slow even when stimulated by certain growth substances like indole acetic acid, and therefore growth experiments have been continued for many weeks. These limitations can be overcome by the use of explants from carrot root, which can be made to grow at a rapid rate under controlled conditions; carrot tissue is also suitable for our special purposes. Another note (5) describes a new technique for the controlled growth of explants of carrot root in liquid media. The present note concentrates upon a striking nutritional effect of coconut milk on the growth of these cultures-an effect which may be demonstrated both in liquid media and on nutrient agar.

The stimulus which emanates from the buds to activate the vascular cambium in the stems of woody trees is commonly believed to be indole acetic acid (heteroauxin) (3), and the slow growth of the carrot cultures of Gautheret and Nobécourt required this substance. In our experiments the effect of a number of substances, added to White's nutrient medium (16) for plant tissue cultures, was investigated. These substances were additional to the usual nutrients (organic and inorganic, trace elements, and vitamin-like growth factors) and included indole acetic acid, growth substances like 2,4-D, and coconut milk. Attention here will be directed only to the relative effects of indole acetic acid and of coconut milk.

Coconut milk, the nutritive, fluid endosperm by which the developing Cocos embryo is nourished, has already found some application in the culture of bacteria (2), fungi and orchid embryos (12), and immature plant embryos (15). It has been claimed (14) that it contains

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both a specific factor for plant embryo development and a thermostable general growth factor, probably indole-3-acetic acid. An isolated reference (1), unsupported by quantitative data, claims that coconut milk stimulated growth of pieces of tissue from below the shoot apex of Lupinus and Tropaeolum. However, the evidence for an unidentified active principle in coconut milk which can foster the rapid growth of carrot cultures seems to be more clear cut than anything hitherto reported.

Qualities which may promote the growth of carrot cultures can be demonstrated in heat-sterilized, filtered, water-clear preparations of coconut milk (pH 5.6-5.9) obtained from mature nuts. Experiments not here reported show that 1% by volume of coconut milk added to an otherwise complete organic and inorganic nutrient medium causes a marked stimulus to growth; at about 15-20% there is an optimum, with marked decrease in growth at still higher concentrations. No growth of carrot cultures occurs in coconut milk alone.

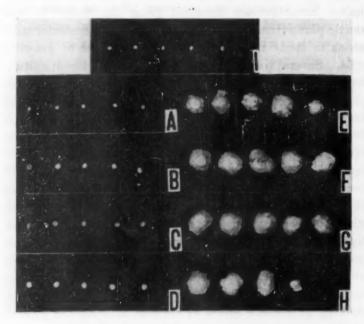


Fig. 1

The qualitative effect of coconut milk on the growth of carrot cultures is well shown in Fig. 1 (half reduction). This experiment was performed in test tubes on nutrient agar (0.8%) at a pH of 5.6. The basal medium contained the inorganic salts, trace elements, sucrose (2%), and the usual organic co-factors, as in White's nutrient solution. The 5 cultures at I show the size of pieces of phloem tissue removed from the carrot at a distance of 1 mm from the cambium and allowed to remain for 21 days on agar medium containing the basal nutrients, but without indole-3-acetic acid or coconut milk. No significant growth occurred. Series A, B, C, and D show the size of similar cultures grown for 21 days on the basal medium to which indole-3-acetic acid was added in the concentrations 10.0, 1.0, 0.1, and 0.01 mg/liter, respectively. Clearly, the cultures stimulated by small concentrations of indole acetic acid grow, but the comparison of E, F, G, and H with A, B, C, and D, respectively, shows the outstanding effect of 15% coconut milk in addition to all other nutrients and indole acetic acid.

In the presence of indole acetic acid the greatest free weight obtained in 21 days was 11.0 mg from 4 mg (mean, 8.2). With added coconut milk the best growth from 4 mg was 327 mg (mean, 184.0). This variability may be much reduced under controlled conditions to be described (5).

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The growth rates of carrot cultures in the presence of indole acetic acid, but in the absence of coconut milk which have been obtained in this laboratory are of the same order as those reported by Gautheret and other (4), but those now obtained with added coconut milk are of an entirely different order of magnitude.

The active principle of coconut milk<sup>2</sup> is not a constituent of the ash, nor is it any of the following vitamin-like growth factors: thiamin, niacin, pyridoxine, glycine. It is equally improbable that it is any of the normal constituents of yeast, malt, tomato, carrot, or liver extract when used at pH 5.6. (Carrot tissue responds slightly to a relatively high concentration of yeast extract, but this response is no greater than that due to indole acetic acid (14), this is clearly not the active substance in question.) The substance is stable to prolonged autoclaving and, since it activity decreases on dialysis, it must surely have relatively small molecules.

These experiments, however, point to much wider problems than those which merely concern carrots and coconuts. Pending the more detailed biochemical investigation which is to be made, the following points suggest themselves:

- (1) An outstanding difference between the carrot cultures which do not grow in the absence of coconut mik (Fig. 1, I), or which sluggishly expand in the presence of indole acetic acid (Fig. 1, A, B, C, D), and those which burst into very rapid growth must surely be in their ability to harness their respiratory energy in protein synthesis, salt and water uptake, i.e. to maintain the processes in the cells which require the use of energy. It would be reasonable, therefore, to seek this coupling mechanism in some effect of the coconut milk which may promote not only carbohydrate breakdown but also the linkage of respiratory energy to useful work.
- (2) The possibility exists, however, that the active principle in coconut milk is not peculiar to carrot tissue and is at least specific for cells which contain carotenoidal Preliminary trials with other plant tissues have been made. Though some have responded to coconut milk, potato cultures under similar conditions do not respond. It is of interest, therefore, that Lazar (9) claims that carotene supplied in the external medium can induce the formation of new roots as well as accelerate growth in both root and shoot of *Impatiens Balsamina* L.

The literature on vitamin A also suggests a possible connection between a constituent of the coconut and vitamin A or carotene (8, 10). Apparently coconut

<sup>2</sup> This active principle has now been found in lyophilized preparations of corn in the milk stage. For access to these preparations we are indebted to Dr. S. A. Watson, of the Department of Agronomy, University of Illinois.

meal, as a partial source of protein in the basal vitamin A-deficient diet, causes the vitamin A to be more effectively used when it is supplied. It has been suggested that there is a factor in coconut meal which, combined with vitamin A, makes the vitamin more effective or which facilitates the transformation of carotene to vitamin A. So far as is known, vitamin A does not affect the growth of plants, but any connection between the physiology of carotene and of extracts of coconut is suggestive in the light of the results here reported. It is also interesting that coconut milk has been known to be used to supplement the nutrition of human infants in the tropics.

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(3) The best growth of animal tissue cultures is well known to be fostered by a preparation of 9-day-old chick embryos (6). The effects due to the "embryo juice" in the culture of animal tissues is suggestive in view of the marked effect here reported by the use for plant tissue cultures of a nutritive fluid for a plant embryo.

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### An Effective Depilatory Formula for Use on Laboratory Animals

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For a series of skin tests in the rabbit it was necessary to remove the hair from an extensive area of the abdomen quickly, completely, and with minimum trauma to the skin. The characteristically soft and luxuriant growth of hair in the rabbit quickly clogs mechanical clippers, whereas shaving is slow and traumatic. Chemical depilatories are frequently used, but the existing formulations either are intended for human use where only slight amounts of hair are to be removed or, when intended for laboratory use, are so caustic and vigorous in action that some burning of the skin ensues even if used cautiously.

In an attempt to circumvent these disadvantages we have prepared a depilatory that has been successfully used on a large number of laboratory animals.

The most common depilatory agents are the inorganic sulfides. Of these, only barium and strontium sulfide are stable and active enough to be practical (1, 3). The barium salt is preferred because it is cheaper and more readily obtainable. The depilatory is prepared by triturating two-thirds by weight of purified yellow barium sulfide powder with one-third by weight of a commercial detergent. We have used "Tide" exclusively, but other detergents such as "Dreft," "Orvus extra granules," and "Swerl" appear to be equally effective. Three full teaspoons (25-35 gm) of the depilatory are mixed with 50 ml of a 10% glycerine-in-water solution until a smooth, creamy suspension is obtained. The area to be depilated is thoroughly wetted down with water. The depilatory is then applied with a wooden tonguedepressor blade and gently worked into the hair. The hair will be seen to gelatinize quickly and practically dissolve. The dissolved hair-depilatory mixture is carefully moved back and forth over the skin surface, particularly where the depilating action seems to be slower. Additional water may be sprinkled on to prevent drying. When the hair is completely removed, the area is rinsed off with a copious amount of water to insure complete removal of any sulfide residue. In this manner the abdomen and chest of a large rabbit can be depilated in approximately 5 min.

The action of the detergent in the mixture is fourfold. It enables the depilatory to come into intimate contact with the hair shaft; it produces a smooth, creamy suspension that is conveniently applied; it acts as a diluent; and it suppresses the odor of hydrogen sulfide that is associated with sulfide depilatories. Ordinary soap powder may be used, but the depilatory action is slower than when a detergent is employed. Water may be substituted for the 10% glycerine, but the latter is advantageous in that it produces a softer and smoother skin through its emollient action and it also retards the rate of drying. Bulfer, et al. (2) found that the monoethylether of diethylene glycol (Carbitol®) acts as a better stabilizer than glycerine, but this compound is not commonly found in the laboratory—a consideration that was used as a guide in formulating the depilatory.

The sulfide-detergent mixture has been used on various species of laboratory animals. In addition to its efficacy in rabbits, equally good results have been obtained with mice and in the preoperative preparation of dogs, cats, and monkeys, with no indication of secondary infections or delayed wound healing.

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- <sup>1</sup> Procter and Gamble, Cincinnati, Ohio.
- <sup>2</sup> Allied Chemical and Dye Corporation, New York City.
- <sup>2</sup> Carbon and Carbide Chemicals Corporation, New York City.

### The Effect of Hypertensin on the Inactivation of Oxytocin by the Serum of Pregnant Women

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A close relationship has been shown to exist between the enzymatic systems that inactivate hypertensin, oxytocin, and vasopressin. When cysteine or glutathione are added to tissue extracts (kidney), red blood cells, or plasma, the capacity of these preparations to inactivate the hormones of the neurohypophysis is increased in direct proportion to the content of hypertensinase (2).

Page (5) pointed out that oxytocinase differs from hypertensinase in its behavior during the course of normal pregnancy. Oxytocinase increases progressively, reaching by the last week of pregnancy a value 1,000 times that of the nonpregnant state; but the increase observed for hypertensinase, in the second half of pregnancy, is only 4-10 times the nonpregnant value.

TABLE 1\*

Tubes	. 1	2	3	4	5	6
Oxytocin (units)	2*	2		2	2	
Hypertensin (units)		0.5	0.5		0.5	0.5
Pregnant serum (ml)				0.02	0.02	0.02

\* The volume of each tube was made up to 2 ml with 0.9% NaCl after adding phosphate buffer, pH 7.3. Before testing, the tubes were incubated from 30 min to 8 hrs. Each solution, previously diluted, was assayed on isolated uterus.

Later, Croxatto, et al. (3), using as a test the effect on blood pressure in cats, showed that at the end of pregnancy the plasma hypertensinase level increases 3-4 times above that of the nonpregnant level, whereas vasopressinase exhibited an increase comparable to that observed for oxytocinase.

The experiments described in this paper indicate either that hypertensinase and oxytocinase have similar enzymatic properties or that there is a great similarity between the chemical structures of their substrates, since hypertensin interferes with the inactivation of oxytocin by the plasma of pregnant women.

Using the uterus of rats and guinea pigs to measure the oxytocinase activity of blood plasma, it was shown that the addition of hypertensin to a mixture of oxytocin and plasma retarded the rate of destruction of oxytocin. The different reagents were mixed in test tubes, the pH adjusted to 7.3 by means of a sodium phosphate buffer, and the mixtures incubated at 37° C for ½-8 hrs. Table 1 shows how the mixtures were prepared. The oxytocin used was a purified product which contained 10 uterotonic units/ml and an appreciable amount of vasopressin. The bath in which the uterus was submerged contained 60 ml of fluid, and the dilution of the mixtures for each tube

varied, depending on the sensitivity of the uterus preparation. Fig. 1 shows some of the results obtained. The hypertensin in the doses employed showed no oxy.

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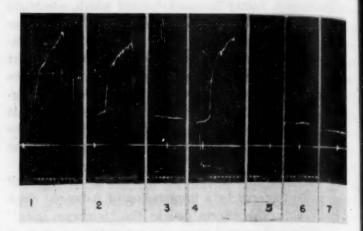


Fig. 1. Contractions of isolated guinea pig uterus, Additions: (1) 0.2 ml (dilution 1:60) of a mixture of 0.8 unit of oxytocin, 0.2 ml of sodium phosphate (pH 7.3), 1.35 ml of 0.9% NaCl in a total volume of 2 ml; (2) 0.2 ml (dilution 1:60) of 0.8 unit of oxytocin, 0.5 unit of hypertensin, 0.2 ml of serum 9th month of pregnancy; (3) same as (2) without hypertensin; (4) same as (2) without pregnancy serum; (5) same as (2) without oxytocin; (6) simultaneous addition of 3 and 5; (7) 0.2 ml of undiluted mixture added in (5).

The mixtures were incubated for 60 min at 37° C, buffered at pH 7.3 with sodium phosphate, and brought to a final volume of 2 ml with 0.9% NaCl.

tocic effect. The retarding effect of hypertensin on the rate of inactivation of oxytocin is readily demonstrated, even with doses of less than 1 unit for every 2-5 uterotonic units of oxytocin.

In view of the fact that certain amino acids are capable of decreasing the rate of inactivation of oxytocin when used at high concentrations (1), the effect obtained in the above experiments might be attributed to amino acid impurities in the hypertensin solution. However, this is not likely because of the dilutions used and also because hypertensin, upon contact with plasma to which oxytocin has been added, loses its inhibitory effect on the oxytocinase after 8-10 hrs.

The possibility of a potentiating effect of hypertensin on oxytocin may also be eliminated, even though the former does increase slightly the uterotonic effect of oxytocin.

The inhibitory effect of hypertensin on oxytocinase slowly disappears as the incubation progresses, i.e. as hypertensin is destroyed.

The addition of cysteine or glutathione does not inhibit the retarding effect of hypertensin.

These results suggest that hypertensin competes with oxytocin as substrate for oxytocinase. Parallel experiments, using as a test the blood pressure in cats, have shown that the inactivation of vasopressin is also inhibited by hypertensin. If these effects are manifested in vivo, it may well be that the humoral mechanism which produces hypertensin indirectly interferes with the hormonal functions of the neurohypophysis.

The hypothesis that the hormones of the posterior

witary have a reciprocal influence on the inactivation hypertensin is under study.

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### the Effect of Browning on the Essential mino Acid Content of Soy Globulin<sup>1</sup>

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Soybean oil meal turns brown during heat processing; fact, the consumer has developed a preference for a own-colored product with a cooked, nutty flavor. Alough some heat treatment seems desirable, it is proble that a large share of the soybean meal on the arket has been overheated (3). Soybeans contain out 30% carbohydrate, which apparently has never en completely characterized. A typical solvent-process al will contain about 0.5% free reducing sugar, and abundance of polysaccharides which can readily yield re reducing sugar. In addition, there are probably her browning reactants, which may be broadly described compounds containing carbonyl radicals. Hence, soyans constitute a system which is conducive to the currence of nonenzymatic browning (the Maillard retion), and this reaction is probably responsible for e brown color which develops in the heat processing.

While there are probably several mechanisms which re responsible for the so-called "heat damage" to roteins, including the proteins in soybeans, we have sen struck by the apparent similarity between the results peorded by Riesen, et al. (6), in which prolonged heating parently destroyed part of the lysine, arginine, and typtophan, and the results we obtained in studying the flects of the nonenzymatic browning reaction upon the lutritive value of casein (5). Consequently, we have etermined the effect on the 10 essential amino acids of sating purified soy globulin in the presence of glucose. A sample of commercial raw soybeans was finely found and extracted with cold hexane. Soy globulin as then isolated by peptization with 10% NaCl and

precipitated by dialysis. The process was repeated twice for further purification. The globulin was then washed with alcohol followed by ether, and dried at room temperature. Browned samples were obtained by refluxing 2.0-gm portions of the soy globulin for 24 hrs in 200 ml of 5% CP glucose and removing the glucose by dialysis before hydrolysis. In an attempt to eliminate heat per se as a factor, the control samples were refluxed for 24 hrs in 200 ml of distilled water. For tryptophan, refluxed samples were hydrolyzed for 24 hrs in 5N NaOH. For the other amino acids 30-hr hydrolysis in 6N HCl was used. The nutritive availability of the essential amino acids in the hydrolysates was determined microbiologically by the method of Stokes, et al. (7), modified by substituting sucrose for glucose in the media to prevent further browning loss (4). Lactobacillus delbrückii LD5 was used for phenylalanine; Streptococcus faecalis R, for the other amino acids. The final concentration of sucrose in the media was 19 gm/liter; both organisms grew well in sucrose instead of glucose. The results are shown in Table 1. These indicate that glucose

TABLE 1
ESSENTIAL AMINO ACID CONTENT OF SOY GLOBULIN
REFLUXED 24 HRS

Amino acid	In water %	In 5% glucose %	Loss in glucose %
Lysine	5.84	4.24	27.4
Arginine	3.43	2.65	22.7
Tryptophan	1.44	1.22	15.3
Histidine	3.21	2.74	14.6
Methionine	1.20	1.24	-3.3
Leucine	7.62	7.53	1.2
Isoleucine	6.28	6.37	-1.4
Valine	5.41	5.23	3.3
Threonine	3.94	3.83	2.8
Phenylalanine	5.10	5.15	-1.0

interaction destroyed 27.4% of the lysine present, 22.7% of the arginine, 15.3% of the tryptophan, and 14.6% of the histidine. It is doubtful if any of the other essential amino acids were affected.

Under the conditions of this experiment, the use of a water-refluxed control turned out to be unnecessary. Apparently the destruction observed was entirely due to the glucose and not to the heat per se, since comparison of the total essential amino acid content of untreated and water-refluxed samples showed the presence of 43.49% and 43.47%, respectively.

The opinion has been expressed in Quartermaster Reports and elsewhere that a toxic, growth-inhibiting substance is produced as a result of the browning reaction. In such a case, one would expect to obtain decreased growth in each of the amino acid assays. Since in our experiments certain amino acid assays gave equal growth responses before and after browning, it seems unlikely that a toxic substance is involved.

Whether the amino acids are nutritionally less available but still chemically present is a disputed point.

<sup>&</sup>lt;sup>1</sup>Scientific Journal Series No. 266, Colorado A & M College gricultural Experiment Station.

<sup>&</sup>lt;sup>2</sup>Present address: Division of Poultry Husbandry, Univerty of Minnesota, St. Paul.

<sup>&</sup>lt;sup>3</sup>The authors wish to thank J. W. Hayward, Archer-Danielslidland Co., Minneapolis, for the raw soy beans; D. F. Green, lerck & Co., Rahway, New Jersey, for the amino acids; and L. L. R. Stokstad, Lederle Laboratories, Pearl River, New lork, for the pteroylglutamic acid.

Our type of inactivation may be different from that of Block, Jones, and Gersdorff (2), since they found that heated and unheated casein yielded the same quantities of lysine after acid hydrolysis. Our conditions are certainly similar to those of Block, et al. (1), who obtained lysine inactivation in high protein cakes. Their recipe included 11% molasses as well as other browning reactants. Paper partition chromatography appears to provide evidence that we are dealing with actual amino acid destruction. In preliminary experiments we have found that an excess of glucose in a solution of the essential amino acids does not interfere with their chromatography unless the mixture has been heated. Upon chromatographing heated and unheated portions of the same glucose amino acid mixture, we have found that the amino acid spots from the heated sample have either declined in density or vanished completely. At the same time new, unidentified "spots" appear, with higher R<sub>F</sub> values than the corresponding amino acids, which are visible by fluorescence under ultraviolet light before heating the paper.

Soy globulin was used instead of whole soybeans for the following reasons: There are difficulties in obtaining a true picture of the amino acid destruction in a heattreated protein food or feed which do not seem to be universally realized. It is not possible to accomplish this with any degree of accuracy by hydrolysis in hot acid or alkali. We have found that, as hydrolysis proceeds, the carbonyl compounds present or produced from carbohydrates or other components react with the amino acids as they are released. This causes a nonspecific, over-all destruction which tends to mask the true heat-processing losses. Enzymatic digestion cannot be used, because overheating is reported to decrease the amount of each of the essential amino acids liberated by enzymes (6). We believe this effect on enzymatic digestion is separate from the destructive effect of browning with which the present article is concerned.

We do not wish to emphasize the actual percentages of loss obtained; they probably apply only to the conditions of individual trials. Statistical analysis, as previously shown for casein (5), succeeds only in demonstrating that the precision of the microbiological assay is excellent. We do wish to point out, however, that there seems to be a pattern of destruction which is significant and would probably apply to other heat processes which cause nonenzymatic browning. Judging from experience with casein (5) and soy globulin, it appears that the amino acids which are attacked by browning an intact protein are chiefly those containing functional nitrogen groups unattached in peptide linkages. There seems to be little doubt that lysine is most susceptible to attack, followed by arginine, tryptophan, and histidine. Presumably the radicals involved are the epsilon amino, guanido, indole, and imidazole groups, respectively. There is no conclusive evidence that any of the other essential amino acids are significantly altered. Apparently the amino groups in peptide or other protein linkages are blocked and do not readily react until hydrolysis

has liberated them. On the basis of this hypothes terminal amino groups should also react.

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### Dyes as Microchemical Indicators of a New Immunity Phenomenon Affecting a Protozoon Parasite (Toxoplasma)<sup>1</sup>

ALBERT B. SABIN and HARRY A. FELDMA

The Children's Hospital Research Foundation and Department of Pediatric University of Cincinnati College of Medicin

The purpose of this preliminary communication is describe a new immunity phenomenon in which dyes certain chemical composition have been found capable indicating the presence or absence of antibody activi This phenomenon was discovered during the course of search for some in vitro manifestation of the action neutralizing antibody on toxoplasma, an obligate, intr cellular protozoon parasite. After finding that to plasma in properly diluted mouse peritoneal exudate con be counted with great accuracy in a standard hemocyton eter, we observed that in mixtures with immune serum toxoplasma remained intact but lost the refractility the exhibited in mixtures with normal serum. incubation at room temperature for several hours, large drops of such mixtures were allowed to dry slowly slides overnight and then were stained with Wright stain, large numbers of toxoplasma could be seen in the preparation from the normal serum mixture, whereas ve few were found in that from the immune serum mixtun Small drops, spread thin and rapidly dried, revealed that with few exceptions, the cytoplasm of the toxoplasma the immune serum mixtures was distorted, poorly stained or unstained as compared with the deep blue staining and granular structure of the cytoplasm of the toxoplasma is the mixtures with normal serum; the chromatin of the toxoplasma appeared the same in both types of mixtures One of us (A. B. S.) had observed a number of years ag that, when alkaline methylene blue was added on a slid to a drop of peritoneal exudate containing toxoplasm immediate deep purple staining of the parasites could b observed under the microscope. When this was done with

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<sup>&</sup>lt;sup>1</sup> Aided by a grant from the National Foundation for Is fantile Paralysis.

<sup>&</sup>lt;sup>2</sup> Senior Fellow, National Research Council.

oxoplasma in mixtures with normal or immune serum incubated at room temperature for several hours), it was bund that with few exceptions the toxoplasma in the inormal' mixtures (Fig. 1, 1) stained deeply, whereas

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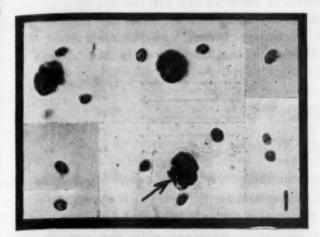
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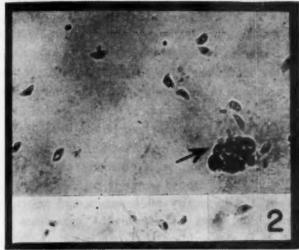


Fig. 1. (1) Toxoplasma incubated with fresh normal Note that serum and then mixed with methylene blue. the organisms are rounded or oval, the cytoplasm stains dark, and the lighter-staining chromatin body is sur-Arrow points to group of rounded by a light zone. Arrow points to group of intracellular toxoplasma. Different fields are presented because of difficulty of getting organisms into focus in wet preparation. (x650) (2) Toxoplasma incubated with fresh immune serum and then mixed with methy-Note that the organisms are mostly creslene blue. centic, the cytoplasm is unstained except in the intracellular group (arrow), and the chromatin remains (×650)Wet preparation.

in the "immune" mixtures (Fig. 1, 2) the cytoplasm of the extracellular toxoplasma was completely unstained. The toxoplasma which were still in their intracellular habitat within the large monocytes all stained deeply in the "immune" mixtures and were apparently protected from the antibody which affected the extracellular parasites. It has long been postulated on the basis of good circumstantial evidence that intracellularly situated viruses, bacteria, and larger parasites are protected from the effects of antibody, and here was visual evidence to confirm it. When these basic observations were once made, a systematic study was undertaken of the characteristics and mechanism of this immunity phenomenon, of the relationship of the antibody involved to the known neutralizing antibody, and of the capacity of dyes of varying composition to act as indicators. The results of these studies are summarized below.

We used the "R.H." strain of toxoplasma, which has had over 400 serial passages in mice since its original isolation from a human case of encephalitis (2). peritoneal exudate obtained from mice, 4 days after intraabdominal injection of a large dose (about 0.1 cc of fresh exudate or 0.5 cc of a 10% suspens on of freshly passaged mouse brain), was optimum for use because (a) it had the largest number of extracellular toxoplasma (3,000,-000-30,000,000/cc) and (b) the toxoplasma were not yet affected by the immune response of the host. In most experiments the exudate was diluted 1: 5 either in physiological salt solution containing heparin 1: 5,000 or serum containing heparin 1:5,000 (to prevent coagulation of the fibringen in the exudate). For quantitative experiments in which the number of stained and unstained toxoplasma were counted to determine the 50% end point of activity, it was important to use the exudate not later than 1 hr after its removal from the peritoneal cavity of the mouse. Toxoplasma immune sera from human beings, monkeys, rats, guinea pigs, etc., were stored in an insulated box containing dry ice, because the neutralizing antibody had previously been found to be thermolabile The mixtures of toxoplasma suspension and sera were prepared in tubes, incubated for 1 hr in a water bath at 37° C (or otherwise, depending on the experiment), and then stored in the refrigerator while the microscopic examinations of the contents were being made, as follows: 0.02 cc of the mixture was put on a slide, one loopful (5 mm in diameter delivering about 0.01 cc) of dye mixed with it, covered with a cover slip (22 mm square), and examined at a magnification of 475 for counting of the stained and unstained parasites, or with the oil immersion lens for studying details of staining. After some trial and error the following dye was selected as standard and prepared fresh every 3-4 days: 3 cc of saturated alcoholic solution of methylene blue + 10 cc of alkaline soda-borax buffer solution of pH 11 (9.73 cc of 0.53% Na<sub>2</sub>CO<sub>3</sub> + 0.27 ce of 1.91% Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> · 10H<sub>2</sub>O). The alkaline pH is important for immediate staining. The alcohol is not necessary except to keep the methylene blue in readily available stock solution. A freshly prepared 0.25% methylene blue solution in the pH 11 buffer also works rapidly and well.

When fresh immune serum (or freshly thawed from the frozen state) is added to a suspension of toxoplasma and the mixture is immediately examined microscopically with the aid of methylene blue, the toxoplasma appear stained (as in a mixture with normal serum), and continued observation for several hours indicates that none becomes decolorized as long as the preparation remains moist. When one makes a fresh microscopic preparation from such a mixture after it has stood for 20 min at room temperature (28° C), one may find that the cytoplasm of 40% of the extracellular toxoplasma is unstained (the chromatin stains blue, red, or not at all, depending on the age of the dye used); at 1 hr this increases to 62%; at 2 hrs to 86%; and at 4½ hrs, to 96% (a varying percentage usually remains unaffected). If the same mixture is incubated at 37° C, the whole process is usually complete in 1 hr. If the immune serum is heated at 56° C for 30 min or left at room temperature for

more than 3 days, it loses its effect completely. It has been found, however, that the specific antibody is not destroyed by this procedure but rather a heat-labile "accessory factor," present in fresh, normal human serum in low concentration (even less in guinea pig serum and not at all in mouse serum), which is necessary for the completion of the immunity phenomenon, as shown in the following summary:

Fresh immune serum + toxoplasma (exudate 1: 5 in saline) > cytoplasm unstained 66 + Heated " 66 66 66 66 stained 66 4 66 (exudate 1: 5 in fresh normal serum) 66 unstained " 66 66 66 " " heated 66 stained " " fresh Fresh normal 66

The amount of this "accessory factor" in human serum is so small that reduction of its final concentration in a mixture to less than 40-50% is sufficient to prevent the immunity phenomenon from affecting any more than 20-30% of the toxoplasma. In searching for a source of "accessory factor," it was found that fresh, undiluted sera of the sheep, cow, horse, dog, monkey, rabbit, rat, and guinea pig could, to a varying extent, by themselves deprive the toxoplasma cytoplasm of its affinity for the dye and therefore did not lend themselves for use as "accessory factor." This substance in "normal" animal sera was proved to be different from specific toxoplasma antibody by the fact that, unlike the antibody in the immune sera from some of these species, it could not be reactivated after heating by the addition of human "accessory factor." This "normal, heat-labile, anti-toxoplasma factor'' has not been encountered in human or mouse sera and is present in only low concentration in some of the animals tested.

When a fresh, human immune serum is diluted in saline and tested against toxoplasma in saline, the effect on the cytoplasmic affinity for the dye is rapidly lost, less than 50% of organisms showing the phenomenon at a 1:2 dilution of the serum. It was found, however, that the limiting factor in this is not the specific antibody but rather the "accessory factor," since immune sera diluted in saline have been found effective in dilutions ranging from 1:16 to 1:1,000 and more when they were mixed with toxoplasma suspended in fresh, undiluted human serum containing the "accessory factor." While the "accessory factor" behaves like complement in many respects, it differs from that operating in the lysis of red cells or in bactericidal and bacteriolytic systems, in that larger amounts of it (or one of its component parts) are necessary for the consummation of the immunity phenomenon affecting toxoplasma. Furthermore the addition of concentrated preparations of the heat-labile C1' and C2' fractions of human complement (kindly supplied by L. Pillemer) to heated normal human serum failed to restore its toxoplasma "accessory factor" activity but did restore its capacity to hemolyze sensitized sheep erythrocytes. A purified, concentrated preparation of "accelerator globulin'' (5) from bovine plasma (the heat-labile AcG factor which accelerates the conversion of prothrombin into thrombin), kindly supplied by W. H. Seegers of Detroit, was inactive as "accessory factor" for the toxoplasma immunity phenomenon.

specific antibody, nor does it by itself affect the affinity of the cytoplasm for the dye. It is apparently only after the "accessory factor" has acted on toxoplasma, which have previously combined with the specific antibody that the cytoplasm is so changed that the normal affinity for the dye is lost. The possibility that the failure of the cytoplasm to stain may be due to a change which reduces the methylene blue to its "leuco" base rather than to a change in the groups which have an affinity for the dye was considered but was regarded as unlikely because (1) when the methylene blue is introduced into the toxoplasma first, no decolorization of the cytoplasm occurs upon incubation with antibody and "accessory factor," and (2) hydrogen peroxide, added to toxoplasma affected by the immunity phenomenon and treated with methylene blue, does not cause the cytoplasm to be stained. It is also evident that one is not dealing here with a change in the permeability of the cell wall of the organisms affected by the immunity process because the dye diffuses into them and stains the chromatin without affecting the cytoplasm. Although hypertonic salt solu tion (8.5%) and formalin (0.5%) do not interfere with the staining of toxoplasma, the immunity phenomenon just described does not occur in their presence.

It was possible to demonstrate by suitable experiment

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(to be described in detail elsewhere) that the specific

antibody can combine with the toxoplasma in the absence

of "accessory factor," and that such toxoplasma are no

deprived of their affinity for the dye and, furthermore

remain fully infectious as tested by titration in mice

The "accessory factor," on the other hand, does not

combine with the toxoplasma in the absence of the

The dyes of the thiazin (thionin, toluidine blue, methylene blue), oxazin (brilliant cresyl blue), and amino-azin (neutral red) groups behave alike in that they stain (in 0.5% concentration) the cytoplasm of normal toxoplasma but not of organisms modified by the effect of specific antibody and "accessory factor." In aqueous solution, without adjustment of the pH to the alkaline side (pH 11), all these dyes act slowly on the cytoplasm and may require from 30 min to 2 hrs for optimum staining. The "acid" character of the normal cytoplasm is indicated by its red staining with neutral red, and the absence of the red color in the cytoplasm affected by the immunity phenomenon—the chromatin stains a deep red-suggests that these "acid groups" have been changed. It is of interest, therefore, that phloxine (xanthene group of dyes) in 2.5% concentration (either aqueous or in buffer of pH 11) fails to stain the normal toxoplasma cytoplasm but stains the cytoplasm modified by the immunity phenomenon. Commercial basic fuchsing (triamino, triphenyl methane group) stains the "im-

gone" cytoplasm more readily than the normal cytolasm (even at pH 11), whereas in the presence of carolic acid (as in the Ziehl-Neelsen stain) both types of stoplasm are stained rapidly and well. On the other and, another triamino, triphenyl methane dye, crystal riolet (hexamethyl pararosanilin) stains the normal more seeply than the immune serum treated cytoplasm. Acid mehsin (the sulfonated derivative of basic fuchsin) as well as Congo red, brilliant vital red, trypan red (dis-azo moup), and sodium 2,6-dichlorobenzenone-indophenol fail stain the cytoplasm of both normal and immune serum reated toxoplasma.

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Toxoplasma killed by freezing and thawing, by heating at 56° C for 30 min, by storage in vitro or even after ertain intervals in dead animals, exhibit the same lack of affinity for methylene blue as those treated with antibody and "accessory factor," i.e. the cytoplasm is unstained and the chromatin is stained. There is a difference, however, in the behavior of the intracellularly situated toxoplasma, i.e. the physical methods of killing toxoplasma affect intracellular as well as extracellular organisms, while in the immune process the intracellular nes are spared. On the other hand, toxoplasma killed by heating at 50° C for 15-30 min or by 0.2-0.5% formalin retain the cytoplasmic affinity for methylene blue. Thus, while affinity of the toxoplasma cytoplasm for methylene blue is not an index of life, loss of this affinity is, nevertheless, an index of death.

Adult albino rats develop a nonfatal infection after intra-abdominal injection of toxoplasma. The heatstable, cytoplasm-modifying antibody appeared on the 5th day after inoculation in a titer of 1:16 to 1:64 and on the 7th day reached a peak titer of 1:256 to 1:1,024 which was maintained for at least 4 weeks. The titer end point is the highest dilution of serum (previously heated at 56° C) which, upon addition to toxoplasma in fresh human serum and incubation for 1 hr at 37° C, effects a loss of cytoplasmic affinity for methylene blue in 50% or more of extracellular toxoplasma. In the rhesus monkey this antibody was not demonstrable in significant amount 3 days after inoculation, was present in a dilution of 1:4 on the 5th day, 1:16 on the 7th, 1:256 on the 10th, 1:1,024 on the 14th, and 1:4,096 on the 21st. Titers of 1:4,096 were also found in sera of immune guinea pigs and rabbits. Many of the sera containing the antibody in high titer exhibited a prozone phenomenon, in that the undiluted serum and sometimes also the 1:4 and 1:16 dilutions were either ineffective we determined whether some of the sera may have "antior affected less than 50% of the toxoplasma. The mechanisms of the prozone has not yet been elucidated, nor have accessory factor'' properties just as some sera are known to anticomplementary.

Many comparative tests have shown that sera which have titers of 1:16 or more of the cytoplasm-modifying antibody also exhibit neutralizing properties in the rabbit skin test (3). It has also been shown that the loss of neutralizing activity resulting from heating or dilution (4) can be restored by the addition of a suitable amount of fresh, normal human serum containing the

"accessory factor." It would appear, however, that the complement-fixing antibody (6, 7) is different from both of these, not only because it may appear later and disappear earlier, but also because sera containing a high titer of the cytoplasm-modifying antibody can be devoid of complement-fixing antibody.

Over 100 sera from human beings with and without histories of toxoplasma infection have now been tested. In mothers without signs of illness who had given birth to children with toxoplasmosis and in children with clinical signs suggestive of the disease, titers of 1:256 to 1:16,384 have been found as long as 2-5 years after probable onset of infection. Titers of 1:16 to 1:64 were found in those with a history suggesting infection 6-7 years ago or longer. Individuals without history of infection or events suggesting infection, whose sera contain neutralizing antibodies, have yielded titers of 1:16 to 1:64. This test has been found more useful than the neutralization test because of its simplicity and because the quantitative data permit differentiation between very old and more recent infection, which is of importance in deciding whether or not certain clinical manifestations in infancy are due to toxoplasmosis, especially when the mother may have neutralizing antibodies as a result of an infection long ago.

This test can also be used to survey the occurrence of the disease in animals. The high titers exhibited by infected rabbits, guinea pigs, rats, and monkeys have already been mentioned. In a recent study (1) on the occurrence of toxoplasma among pigeons in Cincinnati, we found that the one pigeon whose tissues yielded toxoplasma had a serum with a titer of 1:256, while most other pigeons had no demonstrable antibody.

The possibility that cytoplasm-modifying antibodies demonstrable in vitro by a suitable dye-test may occur against such protozoa as Leishmania, trypanosomes, plasmodia, Endamoeba histolytica, etc. needs to be investigated. It is also probable that bactericidal antibodies which have hitherto been demonstrated by cultural methods might become demonstrable in vitro by the use of suitable dyes. Some of the neutralizing antibodies against viruses are heat stable (e.g. the antibody against poliomyelitis virus), whereas others exhibit varying degrees of lability (e.g. dengue neutralizing antibodies become ineffective after heating at 56° C), suggesting the possible operation of a heat-labile "accessory factor." It may be possible to apply the dye technique to the study of some of the viruses by investigating the staining properties of collodion particles with adsorbed virus before and after exposure to action of immune sera.

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### Comments and Communications

### Auxin and Flower Initiation

The recent note by Green and Fuller (Science, October 15, pp. 415-416) on the delay of flowering in petunias by treatment with auxin solutions raises the question as to whether such effects are specifically exerted on flower initiation. It has been known for some years that auxin does inhibit bud development, and this is presumably true for floral as well as for vegetative buds. It would seem that the controls for such experiments should perhaps be not the untreated plants but the vegetative buds of treated plants. This would enable any specific effect of auxin on flowering to be distinguished from general bud inhibition.

In our own experiments with barley, which are being reported elsewhere (Amer. J. Bot., in press), auxin treatments had an inhibitory effect on the vegetative buds. In addition, however, it is of interest that low concentrations, which produced such a vegetative inhibition, definitely increased the number of flower primordia in flowering plants. High concentrations reduced the number of flower primordia. This suggests a parallelism with the known effect of auxins in promoting flowering in the pineapple (H. E. Clark and K. R. Kerns. Science, May 22, 1942, pp. 536-537, and other later workers).

TABLE 1

EFFECT OF INDOLE ACETIC ACID ON FLOWER
INITIATION OF BARLEY

Treatment	Flower primordia per plant	Per cent of controls	
Water control	$26.4 \pm 1.3$		
10-5M IAA	$30.0 \pm 3.3$	114	
10-4M IAA	$34.3 \pm 1.7$	130	
10-3M IAA	$25.4 \pm 1.7$	96	

Variability is expressed as standard deviation of the mean.

Wintex barley plants, which require long days for flowering, were grown for 3 weeks in a 10-hr day and then transferred to a 16-hr day. Groups of 10 plants were treated with solutions of indole acetic or naphthalene acetic acid, ranging in concentration from 0.01 to 400 mg/liter. Each plant was given 1 ml of solution by infiltration through cut leaf tips. Three weeks after treatment the plants were dissected, and the flower primordia were counted and compared with the water controls.

The results with indole acetic acid are presented in Table 1. It will be seen that application of the 10-4 molar concentration increased the number of flower primordia 30% over that of the water control. The 10-5 molar solution had a less pronounced effect. Naphthalene acetic acid produced similar results. At concentrations below 10 mg/liter, the number of flower primordia was

increased. At 10 mg/liter and above, the number was decreased, the decrease being approximately proportional to the logarithm of the auxin concentration. The latter inhibition is similar to that reported by Thurlow and Bowner for Xanthium (Amer. J. Bot., 1947, 34, 603) and by Green and Fuller (loc. cit.). The ability of low concentrations of auxin to increase the number of flower primordia, however, indicates that auxins may not be acting simply in opposition to flowering.

A. C. LEOPOLD and K. V. THIMANN

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Hawaiian Pineapple Co., Ltd., Honolulu, and Harvard Biological Laboratories

### A Note on the Fungicidal Property of Actidione

In a significant article by Kornfeld and Jones (Science, October 12, pp. 437-438) concerning the chemical structure of Actidione, a new antibiotic substance, the comment is made that "this interesting material is highly active against almost all yeasts but is relatively innocuous to other microorganisms."

Interest in this material will be heightened by the discovery by Drs. I. M. Felber and C. L. Hamner, now in press, that Actidione is effective against powdery milder in concentrations of 5 ppm. There are suggestions that Actidione may be effective against other fungi as well. This is an instance of an antibiotic substance derived from a fungus which is effective against a plant microorganism.

H. B. TUKEY

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### Propagation of Metasequoia by Juvenile Cuttings

A note pertaining to the propagation of Metasequoia glyptostroboides should be interesting to those who have read of the recent discovery of living trees of Metasequoia (H. H. Hu. J. N. Y. bot. Gard., 1948, 49, 201-207; G. L. Stebbins. Science, July 30, pp. 95-98) and especially to those who have received some of the seed distributed by Dr. Merrill, of Harvard University.

While the use of juvenile cuttings is not new, there have been few opportunities when this method could be used extensively. However, where so many people have a supply of only seedlings of *Metasequoia*, this method is well adapted for rapidly increasing the number of plants available for testing and distribution.

Seed received by the Division of Plant Exploration and Introduction was sent in May 1948 to the U. S. Plant Introduction Garden, Glenn Dale, Maryland, where it was immediately sown. The resultant seedlings were then potted and grown in the greenhouse. In September a limited number of cuttings were made from the young, lateral shoots of these 5-month-old plants. These cuttings were handled in a routine fashion; that is, the basal leaves were stripped from the stems and the cuttings inserted into a bed of moist sand. Because the stems of these cuttings were very delicate, care in removing the leaves and inserting them in the sand was necessary.

ly 2 cuttings of the entire lot died, and the remaining entings rooted successfully. At the end of 3 weeks examination of the cuttings indicated that roots were ming. The cuttings remained in the sandbed for 5 eks, at which time they were removed and potted. It is a solvious that the original lot of cuttings was being successfully, a second, larger propagation was ide. These have begun to root in a comparable many, with roots appearing in 3 weeks. Apparently, cut
gs made from lateral shoots when the plants are still the seedling stage root easily and rapidly.

The only objection that might arise from the use of the juvenile cuttings is the possibility that prostrate ints or juvenile forms would result. However, since thinese are reported (see Hu) to propagate their test from cuttings, we may expect similar results, for may assume that their cuttings came from the lower rizontal branches and not from the terminals. This saibility will, of course, be determined only when the ttings have grown considerably.

JOHN L. CREECH

nicision of Plant Exploration and Introduction, wreau of Plant Industry, Soils, and Agricultural ingineering, USDA, Beltsville, Maryland

### eience and Social Problems

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With the advent of new, horrible, and efficient weapons destruction resulting from the application of the scitific method to the problem of killing or incapacitating en, a new sense of responsibility has developed among entists. Some have proposed that they refrain from ng their talents in further researches of this kind, hers have forcefully advocated the formation of a world vernment, and still others have proposed that the scitific method now be directed toward a study of the oblems of sociology, economics, and politics with the pe that a resultant better understanding could lead to e development of a society in which war would be elimated. Thoughtful people not actively engaged in sciee have also begun to look to it to provide knowledge hich will assist men in using their ever-increasing power er nature in wise and nondestructive ways.

In a world in which the scientists of a few important ations have no freedom of choice, the first proposal apears to be foolish; it would be equally foolish to ignore be professed objectives of the rulers of these nations and at our trust in a world government. Furthermore, there nothing to indicate that the people of the world are a tready to surrender a sufficient measure of their soverignty to allow a world government to function in any flective way. If a solution to the problem of war is to be found with the assistance of scientists, the third prosal would seem to be the only one offering a significant respect for success.

This approach, however logical, is not as simple as it night appear. Dr. E. U. Condon, in a recent paper Science, June 25, pp. 659-665) discussing science and equrity, remarks: "In short, the greatest contribution or real security that science can make is through the

extension of the scientific method to the social sciences and a solution of the problem of complete avoidance of war." Earlier in the paper he had deplored the reluctance encountered even in civilized countries to accept and extend the use of the scientific method to sociology, economics, and politics. He defined science as "the process of studying and the results of study of the facts of experience derived from a conscious program of observing, while systematically varying the factors of a given situation in order to arrive at a rational understanding of the observational data so obtained." Perhaps an explanation for the reluctance which disturbs Dr. Condon and other scientists lies in this definition of science.

Understandings arrived at as a result of the application of this scientific method to the social sciences would have a high probable accuracy and would therefore provide logical bases for legislative or educational actions. However, it must be noted that in order to vary systematically the factors of a given situation, the scientists conducting the studies of necessity must have control over them. Since it is unlikely that sufficient numbers of people would voluntarily subject themselves to such control, it follows that legislative action establishing it would be required. While it can be argued that the stakes are high enough to justify the risks involved in such procedures, it is unlikely that sufficient support can be developed in this country to permit such a radical change to be made without resort to subterfuge and deception. This is perhaps one reason for the cool reception such proposals have received from the public and the Congress.

Social science studies conducted to date, with minor exceptions, have been observational and statistical rather than experimental, and perhaps this is the kind of research which the advocates of broader application of the scientific method have in mind. Here is, however, another difficulty. Understandings so achieved are only approximations, and in many cases inaccurate approximations at that, due to the inherent limitations of the methods employed. Their accuracy can be improved by subjecting them to experimental verification, but this immediately raises the problem of control again. Under these conditions it is unlikely that there will be unanimity of opinion among scientific specialists as to the meaning of the understandings reached or as to their validity. Positive action based on such a shaky foundation would be definitely hazardous even if the people and their legislators could be persuaded of its reasonableness.

It may be true that expanding the application of the scientific method to social sciences will provide us with knowledge which will lead to the elimination of war. All concerned should, however, recognize the difficult problems to be solved, and scientists should be the first to point them out so that all of the people have a clear understanding of the hazards and difficulties involved.

Meanwhile, a careful appraisal of the differences between the beliefs of science and of the important religious faiths, with due regard for the probable accuracy of each aspect of their respective dogmas, should have at least equal value, relative to the solution of social problems, with observational studies in the social sciences. For the destruction of the religious faith of a large portion of the world's dominant and educated people by the approximations of science has left a spiritual void which is a basic cause for the catastrophic impact of diverse, materialistic, political systems on each other and on the unfortunate, but largely inarticulate, human victims.

In order to fill this void with something more tangible than Dirac's substance having negative energy and mass, it is proposed that a suitable body of specialists in all fields of knowledge prepare a list of the most pertinent facts of experience and observation. An example of a suitable fact would be that there are living organisms on this planet. The next step would be to request representatives of science and religion to present their understandings of these facts together with sufficient supporting evidence to permit an estimate of accuracy to be made. Finally, the facts plus the comparative understandings should be published. It is the writer's belief that such a comparison will demonstrate that there is room in the rational mind for religious faith, which might be the greatest service that science could render man in these times.

R. O. BENDER

R.D. #1, Bridgeton, New Jersey

### The Effects of Allyl Isothiocyanate Compared With Ultraviolet Radiation

A comparative study of the effects of synthetic allyl isothiocyanate (mustard oil) and ultraviolet radiation upon the ciliated protozoan *Spirostomum ambiguum* has been conducted in our laboratory.

Eight to 10 sec of exposure to mustard oil caused striking effects. The same was true when the animal was exposed to ultraviolet for a period of 20 to 30 sec at a wave length of 2,537 A and a target distance of 5 cm. In the majority of cases the posterior end enlarged. Occasionally small swellings lighter in color than the rest appeared over the surface. These changes persisted 4 to 9 days and gradually disappeared.

Mustard oil and ultraviolet caused fragmentation of the macronucleus. So far no changes have been detected in the micronucleus as a result of/either treatment. Details of this communication will be published.

HAROLD E. FINLEY, EDWIN S. SHIRLEY, JR., and JAMES W. WANZA

Department of Zoology, Howard University

### The Earliest Record (ca. 195 A.D.) of Fishing With the Hand<sup>1</sup>

Fishing with the hand is a primitive fishing method widespread throughout the world. On this fishing I am preparing a series of historical papers by continents and regions. It is undoubtedly the oldest means by which primitive man obtained his fish food. Its beginning cannot be dated, but fortunately, an approximate date can be set for the first recorded account.

<sup>1</sup> By fishing with the hand, just that is meant—the use of the human hand without any auxiliary help, unless specifically noted.

Various authorities (?) (without giving citation allege that the classical writer, Aelian (fl. ca. 120 AD in his great work, De Natura Animalium, describes has fishing in Macedonia. There is no English version of the work—not even in the Loeb Library. However, the American Museum library has an excellent Latin edition published at Zurich in 1556. I have made seven searches through the chapter headings, watching for head words, manus, piscator, Macedonia, etc., but in vain. It account may, of course, be buried in the text, but care scanning of this has been unavailing. Should such account ever be found in Aelian, its date (ca. 120 AD would eclipse that in the title of this article.

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Fortunately, an obscure reference in Wm. Radcliffs Fishing from the earliest times (2nd ed., 1926, p. 24 took me to the Greek poet, Oppian (of Cilicia), w flourished ca. 170-200 A.D. The Museum library has t English version of his poem, "Halieutica" (Oxfor 1722). Book IV of this work was translated by Jones. In Book IV, lines 730-739, Oppian writes:

The Diver hardened to the dreadful Toil With artless Force attacks the finny Spoil, Boldly he plunges from ethereal Day, Springs to the Deep, and treads the fluid Way; Firm as on Land along the vaulted Shores The secret Chambers of the Deep explores; Revisits safe the long-suspended Air, And grasps with loaded Hands a captive Pair. The Sargo thus, and tim'rous Shade-fish dies, Nor this his Fears secures, nor that his Size.

Further on, in lines 753-762, Oppian says:

The Swain descends, and singles out his Prey.
Where the sleek Neck and taper Tail displays
A naked Void, his cautious Hands he lays,
With meeting Arms the crackling Captive bends,
Snaps off his Chine, and all his Sinews rends.
Knit in the close Embrace the rest abide,
And fondly in their pointed Fence [of spines] confide.
The Diver joyful of his finisht Toil,
Remounts the Floods and bears the double Spoil.

Oppian next describes, with apt similes, how the Shad fish seeks to hide from the diver, but in vain, and in lin 781-784, he thus concludes the account as follows:

The Fish in careless ease supinely laid The grappling Fingers of the Swain invade. Up from the Deep he springs, and bids the Prey Recant his errors in aerial Day.

Reading these three excerpts from Oppian, one monoconclude that diving and catching sea fishes with the hand was known and practiced by the ancients in classic times. But to fix the date of Oppian's account is weldifficult. One authority gives his year as ca. 170-91 A.D. Perhaps it is better to say that he flourished the last third of the Second Century A.D. Several of the authorities state that he died at the age of 30.

Taking all the facts into consideration, it seems for to say that Oppian's "Halieutica" bears the date of 195 A.D. Certainly, it is the oldest account of fishing with the hand that has thus far come to light. The new oldest—from China—is dated ca. 1325 A.D.

E. W. GUDE

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The American Museum of Natural History

### Obituary

### Sumner Cushing Brooks 1888-1948

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On April 23, 1948, Sumner Cushing Brooks died Bermuda as the result of a heart attack. With seleath, America lost one of its leading cell physilogists, a man known the world over for the exellence of his research in one of the most difficult and, at the same time, one of the most significant elds in modern science.

Sumner Brooks was born on August 17, 1888, in apporo, Japan, where his father, a distinguished griculturist, was teaching at the Imperial College of A few months later, the family regriculture. urned to the United States in order that William enn Brooks, the father, might accept a professorship Massachusetts Agricultural College (now the Uniersity of Massachusetts). Young Sumner Brooks tudied at the Massachusetts Agricultural College and pok his Bachelor's degree there in 1910, specializing botany. From his early years Sumner Brooks had ad an ardent love for nature, a love which persisted broughout his life. He knew birds and flowers as lew men know them; and in his later years, no matter ow engrossed he became in his laboratory experinents, he always found time to study and enjoy the plants and animals of the out of doors. Indeed, just before his death, he was president of the Northern Branch of the Cooper Ornithological Club.

Following his graduation, after a year as an assistnt in the Botany Department of his alma mater, Brooks went to Harvard. There, as a graduate stuent of botany, he came under the influence of the distinguished plant physiologist, W. J. V. Osterhout. At that time Osterhout's laboratory was a center for the study on plant material of the problems of cell physiology, and students were attracted there from far and wide. It was an exciting group with which to be associated. Winters were spent at Harvard; summers, at the Marine Biological Laboratory at Woods Hole. At Woods Hole, because of the close friendship between Osterhout and Jacques Loeb, the cell physiologists from Harvard came under the dynamic influence of Loeb, at that time the leader in general physiology in America.

Brooks took his Ph.D. in 1916 and then left Harvard for a position in the Research Institute of the National Dental Association in Cleveland. There he met Matilda Moldenhauer. They were married in 1917. For the next 31 years the Brookses maintained a deep interest in physiology.

In his first scientific paper, published in 1916, Brooks showed clearly that plant protoplasm is permeable to salts, that sodium chloride increases permeability, whereas calcium chloride decreases it. Numerous other papers on permeability followed, and it was not long before Brooks became one of the world's leading authorities in the field. In 1935 he studied the rate of entrance of deuterium into cells, and in 1938 he led the way in the investigation of the entrance of radioactive isotopes. This latter work showed definitely that for both plant and animal cells the rate of entrance of salt ions was decidedly more rapid than most cell physiologists had believed possible. Other investigators soon confirmed these results, and there have been many studies of permeability by the radioactive isotope method.

In 1941 Brooks and his wife published a monograph on "The Permeability of Living Cells," which was one of a series (Protoplasm Monographs) brought out by Borntraeger in Berlin. The manuscript for this monograph was completed in 1939, but the war brought delays, and it was not until 1944 or 1945 that the book found its way to America. The monograph constitutes an important work in the field of cell physiology and is widely used and quoted.

Although the major portion of Brooks' scientific work is in the field of permeability, he also published important papers in other fields, some of them related. He wrote on the accumulation of electrolytes in cells, on bioelectric potentials, on hemolysis, and on the mechanism of complement action. In due time Brooks generally became recognized as Osterhout's leading student.

Brooks began to teach in Bryn Mawr College in 1919. He went from there to the U. S. Public Health Service, where he stayed from 1920 to 1926. In 1926 he became a professor of physiology at Rutgers University and a year later went to the University of California to serve as professor of zoology. He taught and did research at California until the time of his death.

Brooks traveled widely, usually at his own expense. Wherever he went, he visited scientific laboratories and took time to study animals and plants in the field. His summers were usually spent in Woods Hole. He was highly respected in the Marine Biological Laboratory, and his opinion and advice was

widely sought by workers there. Some years ago he was elected a Trustee of the Laboratory.

Brooks was responsible for the training of a number of graduate students, men who have gone out to do valuable research in the field of cellular physiology. He was loved and respected by them, as he was also by many generations of undergraduates. Everyone who knew him came to have a deep admiration for his gentle spirit and his unselfish devotion to the

cause of science. He did his research work honest and carefully, never claiming more for it than it w worth. He was an honest scientist rather than promoter, and though he attained no great honors awards, his splendid achievement in the field general physiology will speak for him long after his death.

L. V. HEILBRUN

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### NEWS and Notes

K. Starr Chester, until recently head of the Department of Botany and Plant Pathology and director of the Research Foundation of Oklahoma A & M College, has joined the staff of the Battelle Memorial Institute. Columbus, Ohio. In his new position, Dr. Chester will direct the Institute's research program in the agricultural sciences and in plant and animal nutrition.

Dominion Entomological Laboratory at Chatham, Ontario, has been appointed Dominion Wildlife Officer for Ontario under the Dominion Wildlife Service of the Canadian Department of Mines and Resources at Kingston, Ontario.

George C. Decker, of the Illinois State Natural History Survey, Division of Economic Entomology, has been named professor of entomology at the University of Illinois. Dr. Decker will direct graduate research in economic entomology while carrying on his regular work with the Survey.

Reginald H. Painter has obtained leave from Kansas State College, Manhattan, for 1948-49, to accept a postdoctoral fellowship in the Department of Entomology at Ohio State University. He will devote the year to research and writing a book on the resistance of crop plants to insect attack.

second U. S. Public Health Service Cornell) has been appointed an in- U. S. visitor in 1937-38, when he was Postdoctorate Fellowship to continue structor in zoology while Mr. Parker associated with the Department of

enzyme research studies begun a year (M.S., Tennessee) has become an i ago at the National Cancer Institute. structor in physiology. At the Institute Dr. Eiger will work with Jesse P. Greenstein, and later with Prof. Linderstrom-Lang in Copenhagen, Denmark.

David F. Mitchell, former National Institute of Health senior research fellow at the University of Rochester, School of Medicine and Dentistry, and Thomas D. Speidel, dean of the Loyola University Dental School, have been appointed to the faculty of the School of Dentistry, University of Minnesota. Dr. Mitchell, who has been made associate professor of dentistry and will head the Division of Oral Pathology, plans to continue his work Geo. M. Stirrett, formerly of the on experimental periodontal disease and dental caries. Dr. Speidel has Lecture of the current series at the been appointed professor of dentistry and chairman of the Division of Orthodontics.

> Harlan N. Worthley, director of the Agricultural and Textile Chemicals Research Department, Merck & Co., Inc., was recently appointed executive director of the Committee on Chemical Warfare, Research and Development Board, National Military Establishment. Dr. Worthley will assume his new duties January 3.

> Thomas D. Dublin, professor of preventive medicine and community health, Long Island College of Medicine, who was recently appointed executive director of the National Health Council, has assumed his new duties in the National Health Council Building, 1790 Broadway, New York City.

Richard C. Snyder and Prentiss E. Parker, Jr., recently joined the staff of the research program and in the of the Department of Zoology, Univer- academic activities of the School of Irena Z. Eiger has been awarded a sity of Arizona. Dr. Snyder (Ph.D., Electrical Engineering.

Edward Kozicky, representative the U. S. Fish and Wildlife Service has joined the staff of Iowa State Co lege to head the Iowa Cooperation Wildlife Research Unit.

Edward Larson, associate professo of pharmacology, Temple Universit Medical School, has been appoint professor of physiology and pharms cology at the University of Miam Miami, Florida.

Fritz Lipmann, head of the Bio chemical Research Laboratory, Mas sachusetts General Hospital, and ass ciate in biochemistry, Harvard Medica School, will deliver the third Harve New York Academy of Medicine December 16. He will speak on "Bio synthetic Mechanisms."

#### Visitors to U.S.

Oscar Orias, director of the Instituto de Investigacion Medica "Merce des and Martin Ferreyra," Cordoba Argentina, has arrived to serve visiting professor in the Department of Physiology and Pharmacology Long Island College of Medicine. For the next year he will be engaged both research and teaching in the College.

Henry G. Booker, British authority on the propagation of electric waves has been appointed professor of ele trical engineering at Cornell Univer sity, effective this month. Dr. Booker will be associated with Charles B Burrows and others in the developmen

s scientific adviser to the British lation to the sick patient. Broadcasting Corporation and as a sechnical editor.

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M. J. Thirumalachar, lecturer in nycology and plant pathology, Mysore University, Bangalore, India, who has been engaged in research on certain grass smuts in the Department of plant Pathology, University of Wiseonsin, and has visited several pathological and mycological institutions in the U. S. during the last two years, has now returned to India. Returning by way of England, he stopped at the Commonwealth Mycological Institute and Kew Herbarium, Kew, Surrey. While in this country he presented research papers at the annual meeting of the American Phytopathological Society and the Mycological Society of America and also contributed several articles on rusts and smuts to American journals.

### Grants and Awards

The National Health Council has been granted the sum of \$225,000 from the Rockefeller Foundation to promote its program of strengthening the publie health movement in the U.S. over a three-year period. The Council's current program emphasizes the enlistment of more active public participation, in partnership with professional workers, in the field of public health. It is now engaged in aiding local professional and citizen groups in their attempts to bring about full-time, professionally staffed, health departments where these do not exist, and to strengthen the health services of existing departments. The Council's staff is also working with local groups and individuals engaged in forming community health councils to bring together all interested organizations in planning community health.

and Sciences, Boston, recently pre- SPSSI is a division. sented its Francis Amory Prizes for

Merrestrial Magnetism, Carnegie Insti- Brunswick, New Jersey. Dr. Huggins scientists. All reports and studies subntion of Washington, Dr. Booker has presented an address at the meeting mitted for the Award are to be sent in been associated with Cam- entitled "Medical Significance of the duplicate before the contest deadline ridge University, in addition to acting Amory Prize Researches" in their re- to the chairman of the judges, Robert

> Permanent Science Fund has since New York. October 1, approved grants-in-aid his continuing study of cell and tissue Arbor, Michigan. changes in certain dietary deficiencies (\$1,800); Edmund Schulman, University of Arizona, for field study of treering cores in the Patagonian Andes (\$1,500); Robert J. Menzies, Pacific Marine Station, for a taxonomic study of the genus Limnoria on the Pacific coast (\$1,000); and R. B. Lindsay, New England School Science Council, to assist the Council in its 1948-49 work (\$2,500).

The George Washington Carver Foundation, Tuskegee Institute, has received three new research grants from the Continental Can Company, the Corn Products Refining Company, and an anonymous sponsor for establishment of research fellowships. The Foundation, established in 1940 by the late George W. Carver, is engaged in research in the natural sciences and

The Society for the Psychological Study of Social Issues has announced a contest open to all social scientists here and abroad for the best research analysis on reducing international tensions. According to Ronald Lippitt, president of the SPSSI, the Edward L. Bernays International Tensions Award for 1949-50, a \$1,000 U.S. Government bond, will be presented to the individual or group contributing "the best action-related research on some aspect of the problem of reducing international tensions in relations between nations." The Award will be presented to the winner in 1950 at the annual convention of the American The American Academy of Arts Psychological Association, of which the

All research published or completed 1947 to Alexander B. Gutman, New during 1949 and 1950 will be con-York City; Charles B. Huggins, Chi- sidered eligible as well as unpublished eago; Willem J. Kolff, Kampen, Hol- manuscripts reporting completed reland; Guy F. Marrian, Edinburgh; search. The contest, which closes July George N. Papanicolaou, New York 1, 1950, will be judged by a committee

MacLeod, head, Department of Psy-The Academy's Committee on the chology, Cornell University, Ithaca,

Inquiries about the Award should be amounting to \$6,800 to the following: addressed to Ronald Lippitt, president, Virgil P. Sydenstricker, School of SPSSI, Research Center for Group Dy-Medicine, University of Georgia, for namics, University of Michigan, Ann

> F. H. Spedding, director of the Iowa State College Institute for Atomic Research, was the first recipient of a new "Iowa Medal" from the Iowa Section, American Chemical Society, at its meeting December 3 at the State University of Iowa. Established in 1947, the award will be presented annually to an Iowa chemist or chemical engineer for meritorious achievement in these fields.

> A. Chester Beatty, English mining administrator, received the Egleston Medal, awarded him last April by the Columbia Engineering School Alumni Association, at a recent dinner in his honor in New York City. The award citation recognizes Mr. Beatty for "his outstanding achievements in the low-grade copper mines in this country, the exploration and mining of African diamond deposits, and his vision and leadership in the large-scale exploration and development of the northern Rhodesia copper fields, as well as in the development of lead-zinc mines in Yugoslavia."

Stephen S. Visher, Indiana University, received the Distinguished Service Award of the National Council of Geography Teachers at its recent Chicago meeting. Dr. Visher was cited for his contributions to the field of geography as well as his outstanding services in educational geography.

### Colleges and Universities

Yale University School of Forestry will issue its first report on the study of the adaptability of tropical woods for structural and industrial uses early next year. Twenty-five tree species from Central and South America will be covered. The study was initiated in April 1947, under the sponsorship of the Office of Naval City; and Selman A. Waksman, New composed of leading American social Research, to discover new sources of

and toughness, hardness and fire re- vanced graduate interdepartmental projects in the Departments of Medi The latter property determines whether for an integrated attack on the prob- logical Chemistry. According to Wil the species will dull woodworking lems, both scientific and practical, of burt C. Davison, dean of the Medical tested for marine borer resistance to invite Africanists working in anthro- enable the Medical School and ho hold paint, accept glue, resist decay, the aspects of African life falling in and withstand extreme weather con- their special fields, with the aim of ditions. Dean George A. Garratt is providing Africanist work in other in charge of the project.

The provost of the University of Minnesota, Duluth Branch, Dr. Raymond Gibson, recently turned the first spade of soil in the excavation for an all-science building. The event was a memorable one, for it marked the beginning of a brand new campus on the 160-acre tract donated to the University by the citizens of Duluth. The first structure to be built is the \$600,000 first phase of the building which, when completed, will house the Division of Sciences. This week's cover carries a drawing of the proposed structure by A. Reinhold Melander and Roy C. Jones, architect and advisory architect for the project.

The African research program, carried on for more than a decade by the Department of Anthropology, Northwestern University, is to be expanded and intensified in the next three years through a program made possible by a grant of \$30,000 from the Carnegie Corporation of New York. The program will be directed toward an understanding of all aspects of contemporary African culture, with particular reference to the changes in native life as a result of the increasing influences of outside forces upon the African.

The training of research personnel for the African area will be a primary objective. Students will be prepared for field study and aided in working up field materials in special seminars to be set up under Melville J. Herskovits and W. R. Bascom. The extensive

high-grade lumber. The samples have scene, especially periodicals and gov- building was constructed, will probeen subjected to tests for strength ernment reports. A faculty and ad- vide additional space for research sistance, and mineral or ash content. seminar will be instituted to provide cine, Surgery, Physiology, and Physio Certain species have been present-day Africa. It is planned to School, the new research facilities will learn if they might be used for con- pology, economics, education, geogstructing wharves. The concluding raphy, missions, politics, and public series of tests evaluated ability to health to discuss before the seminar schools and departments of the Univer-

> As an initial step in furthering this program of African studies, S. F. Nadel, professor of anthropology, King's College, Durham University, England, will lecture at the University during the summer of 1949 on Africanist and related fields.

The University of Delaware has been awarded a \$7,000 research contract by the Office of Naval Research for fundamental research on the stability of polyvinyl formal compositions. It is hoped that the study, under Harold C. Beachell, assistant professor of chemistry, will provide information on the thermal deterioration of insulation compositions. Dr. Beachell's research will also include a study of infrared absorption of polyvinyl formal, the kinetics of accelerated age testing, and a study of insulation compounds.

The Iowa State College Library is establishing a special collection of leading genetics books and journals as a memorial to E. W. Lindstrom, late head of the Genetics Department (see Science, November 19, p. 572). To be known as the E. W. Lindstrom Genetics Memorial Library Fund, genetics volumes bearing nameplates of the collection will be purchased to supplement books now in the Library. Before his death, Dr. Lindstrom had requested that those desiring to express sympathy do so in the form of contributions for such a collection.

collections of anthropological Africana plans for a new \$120,000, four-story meetings with the Entomological So in Deering Library will be broadened addition to its medical research build- ciety of America, will extend over a by the acquisition of works dealing ing. This addition, the first of sev- four-day period, ending on Thrusday, with other aspects of the African eral contemplated when the original December 16.

pital to expand their program, while is financed largely through outsid grants. Such grants are available for varied research work, but at preser there is a severe shortage of space for such activity.

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It is reported that the lowest tem. perature ever reached in the U. S. has been achieved by staff members of the Ohio State University Depart. ment of Physics and Astronomy Working with a magnetic coolin device, or "cryomagnetic generator," the group obtained temperatures as low as five one-hundredths of a degree above the unattained absolute zero, The generator, just recently put into working condition, was operated by John G. Daunt, Maurice C. Desirant and two graduate students, Clifford V. Heer and A. A. Silvidi. The Ohio State physicists regard their achievement as a step toward still lower temperatures. Plans and preliminary experiments on a nuclear cryomagnetic generator with which temperature estimated at one part in a million above the absolute zero may be attained have already been undertaken. It is felt that the new development will facilitate a detailed study of nuclear problems. At extremely low temperatures all molecular and atomic motions are virtually "frozen out," a condition which permits research into the properties of the atomic nucleus and its interaction with other nuclei.

### Meetings and Elections

The 60th annual meeting of the American Association of Economic Entomologists begins on December 13 in the Hotel New Yorker, New York City. Registration facilities will be located in the Grand Ballroom Foyer. Duke University has completed The sessions, including many joint

the afternoon will be occupied by conmrent meetings of the Sections on plant Pest Control and Quarantine, aniculture, and Medical Entomology. The latter section will meet again in he evening at the same time as the Riometrical Clinic on Entomological Problems, sponsored jointly with the Riometric Society, Eastern North America Region.

The Sections on Insecticides and Extension Entomology will meet on Tuesday. In the morning a symposium will be held on the Toxicity of Insecticides to Plants and Animals Other Than Man, and the afternoon will inelude a paper-reading session relating to Insects Affecting Forests, Ornamentals, Florists' Crops, and Turf.

Wednesday's program will include panel discussion on Formulation of Insecticides and two general sessions, Insects Affecting Cereal and Forage Crops and Insects Affecting Fruit Crops. Of special interest on Wednesday afternoon will be a joint meeting of the Section on Teaching Entomology with the ESA. The annual banquet, at which Harlow B. Mills, chief of the Illinois Natural History Survey, will speak on "The Eaters and the Eaten," will be held at 7:00 P.M. on Wednesday in the Grand Ballroom.

Industrial associations have been invited to present papers on Thursday morning, the concluding day. That afternoon will be devoted to sessions on Insecticides and Application Equipment, Insects Affecting Vegetable Crops, and miscellaneous papers.

The Fourth Annual Analytical Symposium, sponsored by the Anaytical Division of the Pittsburgh Sec-

The meeting will open on Monday Copies of the program and abstracts tative of private conservation organiorning with an address by S. A. may be obtained from Dwight L. zations. Rohwer, president of the AAEE, while Deardorff, Mellon Institute, Pittsary 1.

> Members of the AAAS and the staffs of St. Olaf College and Carleton College met on the night of October 12 to commemorate locally the founding of the Association. Victor Johnson, director of the Mayo Foundation for Medical Education and Research, delivered the principal address, "Methods of the Scientist," which was recorded and later broadcast over the St. Olaf College radio station, WCAL.

Frank Kille, dean of Carleton College, states that "one of the most interesting features of the meeting was the fact that the scientists of various fields both at St. Olaf and at Carleton such a large number of the scientists and Wild Life Management Institute. of the two colleges."

ernments to be represented at a Con- listed below ("G" = government; ference for the Establishment of an "S" = societies or organizations): International Union for the Protecprotection of nature.

The U. S. group was as follows: States, G & S; Venezuela, G & S. tion of the American Chemical So- Ira N. Gabrielson, president, Wild Life ciety, will be held January 20-21 at Management Institute, Washington, represented were: United Nations, the Hotel William Penn, Pittsburgh. D. C., chairman of the U. S. Govern- UNESCO, Pan-American Union, In-One feature of the symposium will be ment delegation and private conser- ternational Office for the Protection of a talk on "The Role of Reaction Ki-vation organizations; Harold J. Cool-Nature, International Union of Direcnetics in Analytical Chemistry," by idge, executive secretary, Pacific tors of Zoological Parks, International I. M. Kolthoff. At the symposium Science Board, NRC, U. S. Govern- Council of Scientific Unions, Internabanquet, scheduled for the evening of ment delegate and representative of tional Union of Biological Sciences, January 20, Dean Burk, of the Na- private conservation organizations; International Committee for Bird tional Cancer Institute, will speak on William Vogt, chief, Conservation Sec- Preservation, and Pacific Science Asso-"Cobalt and Iron Chelation in Bio- tion, Pan-American Union, observer ciation-Standing Committee for the chemical Function and Antibiosis," and representative of private con- Protection of Nature in and Around The complete program will be pub- servation organizations; and George the Pacific. lished in an early January issue of Brewer, vice-president, Conservation

The following U.S. organizations burgh 13, Pennsylvania, after Janu- interested in conservation, as well as international organizations, accepted the official invitation to the Fontainebleau Conference and authorized one or more of the four U.S. delegates to represent them officially at the foundation meeting of this new International Union: American Committee for International Wild Life Protection, American Geographical Society (represented by W. Phelps of Venezuela), American Nature Association, American Ornithologists' Union, Boone and Crockett Club, Conservation Foundation, Izaak Walton League of America, National Association of Audubon Societies, National Parks Association, National Research Council, National Wildlife Federation, New York Zoological Society, Pan-American Union, Smithsonwere called together in a common ian Institution, Standing Committee meeting. Since the close of the war for the Protection of Nature in and no other occasion has brought together Around the Pacific, Wilderness Society,

Countries sending either govern-The French Government, in asso- mental delegates, delegates of private ciation with UNESCO and with the or semiprivate organizations or soassistance of the Swiss League for the cieties concerned with nature protec-Protection of Nature, invited 42 gov- tion, or both, to the Conference are

Argentina, G & S; Australia, S; tion of Nature, which was held at Austria, G & S; Belgium, G & S; Fontainebleau from September 30 to Bolivia, G; Brazil, G & S; Canada, S; October 7. This was in accord with Denmark, S; Dominican Republic, G; the final resolutions of the Interna- Egypt, G; Finland, G & S; France, G tional Conference for the Protection of & S; Great Britain, G & S; Greece, G; Nature held at Brunnen, Switzerland, Iran, G; Italy, G & S; Luxembourg, June-July 1947. Each country was G & S; Monaco, G; Netherlands, G & also requested to send a delegation of S; New Zealand, S; Nicaragua, G; representatives of invited scientific and Norway, S; Panama, G; Peru, S; Potechnical groups concerned with the land, G & S; Siam, G; Sweden, G; Switzerland, G & S; Syria, G; United

International organizations officially

The 130 members of the Conference Chemical and Engineering News. Foundation, New York City, represented 123 priject but was also a tribute to the tional Parks and Conservation Areas, of Nature, over a long period of time, UNSCUOR to the Proposed UNESCO and particularly to its secretary-gen- Conference. eral, Mr. J. Buttikofer. The preparawith the assistance of UNESCO.

established on a broad base.

Swiss League, was elected president of reserves in many parts of France. the Conference, and after four days cieties were invited to participate. the writing into the constitution of the

termined that the seat of the Union, entire document: upon invitation of the Belgian Governthe beautiful and useful magazine, Pro tion of human civilization." Natura, of which he is founder and editor.

a valuable technical symposium, with will soon ratify this document, that Prof. Roger Heim as chairman, was the 123 private or semigovernment held under the auspices of UNESCO. societies and organizations represented 8-9, Hotel Commodore, New York City.

vate or semigovernmental societies or Organized by its Natural Sciences Di- at the Conference will ratify the organizations from many parts of the vision, this symposium dealt with 6 signatures within the specified time world and 9 international organiza- subjects of special interest: Legislations with a common interest in con- tion and Action by Governments to servation or nature protection. The Preserve Nature, The Scientific Manattendance at the meeting not only agement of Wild Life, Big Game Conmanifested a wide interest in the sub- servation in Africa, Concepts of Napreparations for the meeting made by Fauna Conventions and International the Swiss League for the Protection Legislation, and Relationship of the

The meetings were held in the magtions for the Conference were also a nificent Palace at Fontainebleau, and tribute to the Organizing Committee of there were excursions to the Forest the French Government under the chair- and beautiful nearby chateaux, as well manship of Dr. Achille Urbain and as receptions and entertainments characteristic of warm French hospitality. The plenary session was opened by There was also a presentation of a gracious welcome on behalf of the "Tovarich" by a famous troupe of French Government and the city of actors from Paris, and a state banquet Fontainebleau, followed by a speech was arranged by the hosts as the cliby the director-general of UNESCO, max to the Conference. This was Dr. Julian Huxley, who expressed the greatly enjoyed by everyone. The Conhope that the new Union would be ference was followed by a week of field excursions to important nature Dr. Ch. J. Bernard, president of the areas such as the forests, parks, or

Perhaps the most important Ameriof meetings devoted to drawing up a can contribution, aside from trying to constitution, the Union was founded establish the kind of a Union that can and held its first General Session at hopefully expect wide support from which all who provisionally signed the nations, private societies, and interconstitution for governments or so- national organizations everywhere, was The U.S. delegation, following official Union of a very much broader definiinstructions, did not sign even provi- tion of Nature Protection, and a sionally on behalf of our Government, greater emphasis on conservation edubut they did so for the 15 private cation than was contemplated in the organizations that they represented, widely circulated Brunnen provisional The new Union elected its officers draft. The U.S. version included a and Executive Board, established a preamble opening with the following budget, appointed standing commit- definition of "The Protection of Natees, drew up a program of work, ap- ture" which was constantly mentioned pointed its secretary-general, and de- in quotation marks throughout the

"Whereas the term 'Protection of ment, would be in Brussels. The Union Nature' may be defined as the preseralso elected Mr. P. G. Van Tienhoven, vation of the entire world biotic comof Holland, its first honorary member munity or man's natural environment and paid special tribute to the work of which includes the earth's renewable Mr. J. Buttikofer in connection with natural resources of which it is comthe preparation of the Conference and posed and on which rests the founda-

There is reason to hope that the 18 governments that provisionally signed During several days of the meeting the constitution, as well as many more,

and that additional appropriate organ izations will apply for early admis The private society dues an sion. established at 200 Swiss francs (about \$40) a year.

The first elected officers of the Union are: president, Dr. Charles Jear Bernard (Switzerland); vice-pred dents, Mr. Harold J. Coolidge (U.S.A.), Mr. Henry G. Maurie (United Kingdom), and Prof. Roge Heim (France); members, Dr. Box Benzon (Denmark) ICPB, Dr. Nil Dahlbeck (Sweden), Prof. Waler Goetel (Poland), Dr. J. K. van de Haagen (Netherlands), Prof. H. Hum bert (France), Prof. V. Van Straele (Belgium), Dr. Vellard (Peru), Prof. Renzo Videsott (Italy), Mr. William Vogt (U.S.A.), and Dr. José Yepe (Argentina); secretary-general, Mr. Jean-Paul Harroy (Belgium).

All inquiries should be addressed to the secretary-general at the office of the Union, 21 Rue Montoyer, Brussels, Belgium.-H. J. C.

Correction: In the article on "Natural Resources Problems in Japan," by Lt. Col. Hubert G. Schenck (8cience, October 8, pp. 367-372), the last sentence of paragraph 2, page 369, should read: "Production has been increased from the 1945 level of 4,000, 000,000-5,000,000,000 pounds to more than 7,000,000,000 pounds which is about as much as the present fishing area can support." In the article the pounds were erroneously given in millions instead of billions.

### Make Plans for—

In last week's issue (p. 642) we erroneously reported that the Mycological Society of America, the Botanical Society of America, Inc., and the American Society of Plant Physiologists were scheduled to hold meetings in December of this year. The next annual meetings of these societies are scheduled to be held in 1949 in connection with the AAAS meetings in New York City. We regret that this error occurred.

Gerontological Society, January